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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Heat-Treated Cast Iron and Engineering.

At the recent meeting of the Institute of British Foundrymen, a comprehensive Paper was submitted by Mr. J. E. Hurst, dealing with the hardening of cast iron. This Paper embodied the author's recent researches on the potentialities of hardening and tempering of cast iron, particularly alloy cast iron, and the nitrogen-hardening of cast iron, and gave rise to a considerable amount of interest and discussion. The results of these researches have shown that cast iron, plain or alloyed, is susceptible to heat-treatment in a somewhat similar manner to steel, and if such treatment is carefully controlled, hardened irons can be obtained with reliable and enhanced properties.

The advent of such irons is of importance to engineers as well as to ironfounders. To the former they are a new material which ought to be of considerable value in meeting many of the problems with which they are confronted, while to the latter, their use extends and consolidates, still further, cast iron as an engineering material. We would suggest that heat-treated cast iron should appeal to engineers owing to the fact that here apparently is a material which can be cast with comparative ease, but which, when treated, acquired properties of a nature similar to cast and forged heat-treated steel. Motor engineers have recognised the commercial practicability of such irons, and during the last three years a considerable number of cylinders for motor cars have been manufactured of such material. The use of heat-treatable irons, however, is not confined to motor cylinders, and they are equally suitable for such parts as pistons, piston rings, valve and pump parts, and for the production of cast-iron permanent-mould or die castings. Nitrogen-hardened cast iron has been experimented with for cylinder liners and ought also to be suitable for piston rings, pump liners, cams, spindles and die blocks.

The extent to which the engineering industry will use these new materials will depend largely on the results obtained from the parts already in service, and also on the further work of the metallurgist or physicist in determining for such materials the properties which are of vital importance to the engineer. Work so far has been confined to methods of treatment and determination of strength and hardness, but it is essential that further knowledge is obtained of such properties as resistance to heat, resistance to scaling, resistance to corrosion, rigidity, wearing qualities and fractional properties. The early determination of such data is of extreme importance, particularly as the initial investigations have given such promising results, because it is with such information before him that the engineer will decide whether cast iron so treated will take the place of steel castings; and heat-treated, case-hardened or nitrided steels for many parts.

A Further Step.

As soon as the original tariff schedules issued for the iron and steel trade were made public we drew attention in our columns to, and urged immediate action, in respect of two important points affecting the foundry trade. The first dealt with pig-iron, in respect of which no duty beyond the original 10 per cent. was imposed, and the second to castings under one hundredweight; the additional tariff on castings only applying to those over this figure. Under the new schedule issued during the past few days both these points have been taken care of. The additional duty now applies to pig-iron other than charcoal-smelted iron, which, in the form of Swedish iron, is a valuable raw material for the Sheffield trades which can be scarcely said to be produced in this country, so that it does not compete with the home product. The clause relating to castings apparently covers all kinds, iron, steel and non-ferrous. Time is required to show just how the importing of castings in the form of machinery will work out. Nobody would desire to exclude the entry of machines required for our industries not produced at home, yet we think that all castings required in such machines can easily be produced and machined in this country. Finally, we hope that the precise form of words used in the clauses will not make it possible for material to come in because it has been heat-treated or finished in any way, thus opening the way to evasion.

The revolution effected in a few weeks is remarkable. The foundry industry is now not merely a protected industry. It is a highly-protected industry. What will it do with the opportunity? There is neither the need for nor likelihood of the kind of rationalisation called for and proceeding in the steel industry, referred to in our last issue. At the same time, the development of continuous production methods involving capital outlay, the increase in number and lightening of quality in specifications, the development of metallurgical technique, all tend to exclude the kind of competition so often complained of in the past. From the back-street founder who starts without capital, proceeds without technical knowledge or cost data, and inevitably ends in the bankruptcy court, after his operations have very nearly placed in the same position established foundries whose overheads take care of these charges. The manufacturers' association is required not to keep up prices, but to keep them down, and public opinion will make itself felt in this connection. We therefore urge every founder to link up with his trade association so that his representatives may, through that association, make the most of these present opportunities. Once lost, they may never recur.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

German Foundry Educational Facilities.

To the Editor of The Foundry Trade Journal.

Sir,—In your issue of the 2nd instant you printed a short article by Mr. Pearce, the Director of the Cast Iron Research Association, which contained incorrect and misleading information relating to his recent visit to the Technical High School of Aachen. Mr. Pearce stated that the Technical School at Aachen was the only one in Germany which had university rank and which could grant a university degree. Neither statements are correct.

I have for the last few years taken great interest in the technical colleges of Germany, and have visited a number of them and have spent considerable time at Clausthal. There are three technical high schools and two bergakadamies in Germany of which I give you the names:—

. Technical High School, Aachen, Prof. Dr. Eilender and Prof. Dr. Piwowarsky. Technical High School, Berlin, Prof. Dr. Durrer and Prof. Dr. Hanemann. Technical High School, Breslau, Prof. Diepschlag. Preussische Bergakadamie, Clausthal, Prof. Dr. Ing. Paschke. Sacksische Bergakadamie Freiberg, Prof. Dr. Maurer.

At Clausthal they very specially teach blast furnace and foundry practice and have a most up-to-date modern foundry plant, the best of its kind I have ever seen attached to any college or university. Both the foundry equipments at Aachen and Clausthal were supplied largely by financial grants from the German Iron Metallurgists, the association of German foundrymen, and the Union of Founders, and much of the actual apparatus and plant were given by foundry-plant manufacturers.

All the five colleges can, and do, hold examinations for the degree of Doctor of Engineering, and are recognised and granted power to accord degrees.

At Clausthal they have also special faculties for mining, metallurgy, chemistry and engineering proper and the standard of education in all these subjects ranks and is very high. Incidentally also they have one of the finest Mineralogical and Geological Museums in Europe. The laboratories and lecture rooms at Clausthal, and in fact at most of the other colleges, are the most perfectly fitted with every modern appliance, many of which are entirely unknown in this country.

As a very complete proof of my statements I enclose various illustrated pamphlets giving particulars of Clausthal. These books give lists and times of the various technical courses taken at Clausthal Bergakadamie.

Incidentally the full-time course for a Doctor of Engineering degree is five years, during which period every student is instructed in every technical and practical feature of his particular branch of study, and each and every student during vacation must go into iron or steel works foundries, chemical works or mines, and do practical work during most of his vacation; and a course of visits to various works each year is conducted by the various professors, both in Germany and abroad.

It is a fact that many of the poorer students actually earn sufficient money during their vacations to pay their college and living expenses during term. I would also mention that the fees and living expenses for students in these technical college towns have been reduced to the absolute minimum so as to bring them within reach of the poorest students desirous of following any special branch of these sciences and professions.

I hope in fairness to all these colleges that you will publish this letter, as Mr. Pearce's statement might easily do serious harm to these well-known and excellent High Schools and Bergakadamies, which I am sure he would not for a moment desire.—Yours, etc.,

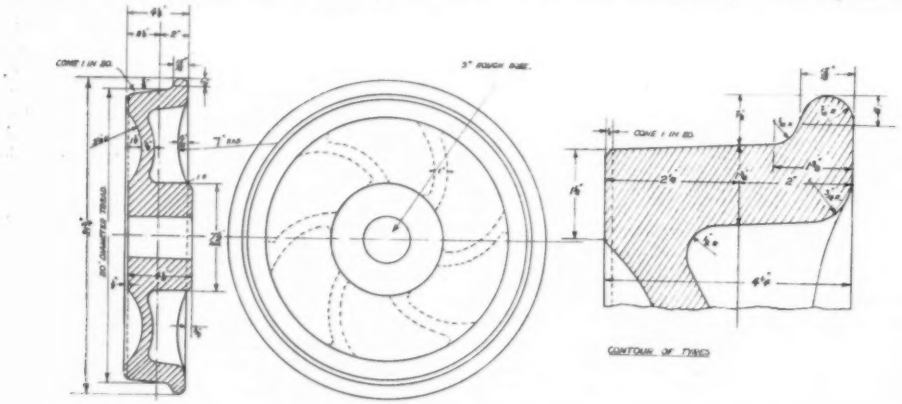
John A. Smeeton.

15, Victoria Street,
Westminster, London, S.W.1.
June 16, 1932.

Chilled Cast-Iron Car Wheels.

To the Editor of The Foundry Trade Journal.

Sir,—The following problem may prove of interest to some of your readers, as it raises the question whether or not the article in question can be manufactured in India at all. We had to make a quantity of chilled cast-iron car wheels to the enclosed drawing. The specification called for $\frac{3}{8}$ in. minimum depth of chill on the tread, and for the usual falling-weight test on the centre of the wheel, the rim being supported at three points (five blows from 1-cwt. weight falling 6 ft.).



We started out by using our ordinary cast-iron mixture, but with silicon reduced to 1.0 per cent. The resulting depth of chill was only $\frac{1}{8}$ in., which was much too small. This iron withstood not only the specified falling-weight test, but much more, blows of 1 cwt. from 30 ft. having no effect. The weight bounced like a tennis ball without injury to the wheel.

We soon found that to obtain $\frac{3}{8}$ in. chill was a very difficult matter. Our second mixture contained:—Total carbon, 3.0; silicon, 1.65; nickel, 0.5 and chromium, 0.5 per cent. The result of this was to produce a chill of about $\frac{3}{16}$ in. behind which was a gradually greying section, the gradation from white to grey occupying half an inch. At the same time, considerable trouble was experienced through cracking of the chilled shell, which was not minimised at all by stoving the job immediately upon casting.

Our last effort was made with a mixture approximating to the following analysis:—Total carbon, 3.0; silicon, 0.9; nickel, 0.5 and chromium, 1.0 per cent. The chill (white iron) had a depth of rather over $\frac{1}{4}$ in. and partial chilling penetrated to a considerable depth, in fact, the whole flange and part of the web were partially chilled. This would probably have met the chill specification, but we were immediately in trouble because over 80 per cent. of the wheels cast had the chilled treads cracked on opening the mould.

The standard "No. 2" pig-iron available in India is made to the following analysis:—Carbon, 3.9 to 4.0; silicon, 2.25 to 2.75; phosphorus, 0.2 to 0.3 and sulphur less than 0.3 per cent.

In the end we had to confess to failure. We do not believe that ore exists in India to give the required results, and wonder if anyone has tried to meet a similar specification without resorting outright to malleable iron practice?—Yours, etc.,

J. Downie,
Manager.

Angus Engineering Works,
Angus, Bengal, India.
June 2, 1932.

Random Shots.

In connection with the correspondence anent Wiltshire brass hardware, the Editor has received a letter emanating from "Dubb & Parsons, Limited," a document which is of such illuminating interest that it merits immediate publication. Accordingly, it is reproduced below in all its unedited glory.

* * *

DUBB & PARSONS, LIMITED,
Wiltshire.
London Office.

Sir,—Although I do not think we are responsible for the brass hardware to which Mr. Newtown Ellis refers, perhaps you may be interested in the fascinating, and almost unbelievable, history of our firm, which indeed reflects the whole course of our rough island story.

Dubb & Parsons was founded by Quintus Curius, a centurion in the Roman Army of Occupation, in about 100 A.D. From the first our production seems to have been varied and to have deviated from our modern ideas of foundry practice. Records show that we forged Excalibur, a sword for King Arthur, which unfortunately was lost in a mere. The obscurity which shrouds our records was lifted in 1066 A.D., when Le Sieur de Montparnasse, Bishop of Bayonne, came over with William the Conqueror, and used his share of the loot to buy up half our 6½ per cent. Cumulative First Preference shares. His position at court enabled us to secure most of the army contracts for chain mail.

Our works were burned down by a band of friars in the succeeding century. (They wanted a fire to do their frying.) This was a dead loss to us, as the government of Richard the Glickstein (of Lyons) had appropriated the funds of our insurance company to pay War Loan on his last crusade.

After this our records fail us for some hundreds of years. Our files consist solely of one signed photograph of Fair Rosamund. In the reign of Henry VIII we secured a lucrative contract for the royal marital executions, axe-heads, supplying of.

Our records show that we did a brisk trade in instruments of torture and death. Bloody Mary, whose picture long graced our Board-Room walls, was perhaps our greatest benefactor, but we did quite well in the succeeding reigns. We supplied the axes which ended the careers of Charles I, Mary Queen of Scots, and numberless lesser fry. About this time we tried to popularise a cast-iron stake, which could be used over and over again at the Smithfield burnings, instead of the wasteful method of using a new wooden one each time, but only the Scotch king, James I, was attracted by the idea.

(*Concluded on page* 389.)

Institute of British Foundrymen.

ANNUAL BANQUET AT NEWCASTLE-UPON-TYNE.

On Wednesday evening, June 8, the annual banquet of the Institute was held at the Grand Assembly Rooms, Barras Bridge, Newcastle-upon-Tyne. There was a distinguished gathering of members and guests, accompanied by their ladies, and after dinner they enjoyed dancing until a late hour.

The President was in the chair, and was accompanied by Mrs. Stobie. The company also included the Deputy Lord Mayor and Deputy Lady Mayoress of Newcastle (Councillor and Mrs. J. Crosby), the Sheriff of Newcastle (Councillor J. Leadbitter), Prof. Henry Louis, M.A., D.Sc., A.R.S.M. (Bessemer Medallist, and a Past-President of the Iron and Steel Institute and the Institution of Mining Engineers), Lieut.-Col. P. H. Ionides, D.S.O. (Vice-Chairman of the Armstrong Whitworth Group), Mr. E. J. George (managing director, Consett Iron Company, Limited), Mr. W. Scott (Senior Vice-President, Newcastle and District Branch of the Institute) and Mrs. Scott, and many Past-Presidents of the Institute.

The Toasts.

The loyal toast having been honoured,

LIEUT.-COL. P. H. IONIDES, D.S.O., proposed "The City and Commerce of Newcastle-upon-Tyne" in a speech which was both witty and serious. In the course of it he said that Newcastle was a city of extraordinary historical interest. The records extended back to the time of Hadrian, the first Roman Governor of this district, most of whose time seemed to have been spent in keeping the unruly Scots on the proper side of Hadrian's Wall. There was a perpetual state of agitation, and Col. Ionides suggested that the original Roman training and, after the departure of the Romans, the continual raids of the Scots, had developed a hardiness, a physique and character in the Northumbrians which had been largely responsible for the success of the industries of Newcastle in later years.

He referred to the high-level bridge over the Tyne at Newcastle as a feature of peculiar interest to foundrymen. It was designed and built by Robert Stephenson, who was the son of the Robert Stephenson who had become so famous in connection with railway development. The bridge consisted of six spans, each of 125 ft.; in each span there were four arches, and in each arch there were four segments, and they were all made of cast iron. The bridge was built in 1849, and, with very slight additions in the form of steel ties, it had stood to this day. It carried a main-line railway, a main road and two lines of tramways, and the fact that it was carrying modern traffic was an extraordinary tribute to the builder.

Discussing Newcastle's coal interests, he said that normally Newcastle exported about 18,000,000 tons of coal per annum. Alongside the coal industry there was the shipbuilding industry. To Newcastle belonged the credit of having built the first turbine-driven vessel, the "Turbinia," with which Sir Charles Parson's name was so closely connected. This vessel was the pioneer which had led ultimately to the building, on the Tyne, of such ships as the "Mauretania," which had held the speed record for the Atlantic crossing until beaten by the "Bremen" and the "Europa," which were 20 years younger. The normal output of shipbuilding in Newcastle was 350,000 tons a year, and the normal output of marine engines was approximately 375,000 indicated horse-power, or thereabouts. It was extraordinarily tragic to note the idleness in the shipyards and the marine-engine shops under the prevailing conditions of depression. We were suffering—and the Tyneside suffered almost more than any other part of the country—from the complete collapse of international trade. The first sufferer from such a collapse was the shipbuilding industry, because there was no demand for ships to carry goods from one country to another. That was the reason why, on the Tyne, there were dozens of berths empty.

New Tyneside Industries.

All of us would turn our eyes to Lausanne, to the Ottawa Conference, and to the later conference which it was expected would be held in London, on international trade. He, personally, believed that the key to the situation lay in the United States of America. Ever since the war the United States had been exacting tribute from an impoverished Europe, and, by reason of the high tariffs operating in America, that tribute could be paid only in gold. The result was that America had accumulated most of the gold in the world, so that other countries could not trade with the United States or with each other. Thus we had the picture of the United States almost choked with gold, and some of its people almost starving. The condition of affairs there was really lamentable, and those who had not friends living there had no conception of the conditions. His belief was that the recovery of the world would come with the recognition in that great country of the injustice of insisting upon the payment of reparations and war debts under existing circumstances.

In view of the prevailing depression, Newcastle had had to turn its attention to industries which were entirely new to it, and he could not find words with which to pay an adequate tribute to the amazing fertility and adaptability of the Newcastle engineer and foundryman. Marine engineering was dead, and steam locomotives were not being ordered, and the Armstrong works had had to turn attention to commercial vehicles and other products which were not made in Newcastle hitherto. The manner in which not only the staff but also the workmen had tackled the new problems spoke volumes for their ability and engineering genius. They had been able to produce the most difficult types of castings after comparatively few weeks' experience, whereas most people required years of experience. Lighter industries also were growing up in the city, and they would help during the difficult times until shipbuilding and coal mining, upon which Newcastle had depended so much, recovered.

Three Notable Anniversaries.

The DEPUTY LORD MAYOR OF NEWCASTLE said he was in some difficulty in responding to the toast, because on occasions such as this he was sometimes called upon to listen to attacks upon the administration of the city, and declarations that the rates were far too high and that the money collected was badly spent. On this occasion, however, there was nothing of that kind to reply to, so that he did not know what to say. (Laughter.) However, he must assume that Colonel Ionides and the great undertaking which he represented were entirely satisfied with the administration of the city, with the manner in which the money was spent and with the assessments made upon them for local rates.

During the week of the conference, there were being celebrated in Newcastle the anniversaries of some rather important events in local and national history. Gas lighting was first introduced into Newcastle on June 6, 1807. He believed that gas was an important factor in some classes of foundry work, so that it was perhaps appropriate that gas should be referred to on this occasion. June 7 was the anniversary, and the centenary, of the passing of the great Reform Bill of 1832, for which the Grey family, who were so closely concerned with Newcastle, had been principally responsible. Charles, Earl Grey—a monument to whom was erected in the centre of Newcastle—was Prime Minister at the time of the passing of the Reform Act. Again, June 9 was the anniversary of the birth of George Stephenson. It was sometimes claimed that George Stephenson was the inventor of the locomotive; he had not invented the locomotive, but he was certainly the engineer who had made railways a commercial and practical proposition in this country and throughout the world, and perhaps that was an even greater achievement than the invention of the locomotive itself.

Whilst one did not wish to seek consolation from the greater difficulties of other people during these times of depression, the Deputy Lord Mayor pointed out that there were some factors in the world which gave us some comfort. In the first place, the Government of Germany was in a very precarious position, whereas we had a Government with a great majority, and which was really a Government. Again, the United States were in great difficulties, the South American republics were in bankruptcy, and there were difficulties in other countries throughout the world. We were paying not only our own debts but also the debts of other peoples. So that there was not so much for us to worry about.

Commenting on the success with which new industries had been developed in Newcastle, he said that when visiting the Commercial Motor Vehicle Exhibition in London a few months previously he had been greatly impressed by the exhibits of the wonderful new Armstrong motor vehicles using heavy oil, and by the remarkable number of orders which had been booked for those vehicles. As representing the city, he took the opportunity to wish this enterprising firm every success in their efforts to bring back prosperity to this district and to the country as a whole. Finally, he said that other encouraging factors were that the bank rate was down to 2½ per cent., that to all intents and purposes there were no strikes in this country.

The SHERIFF OF NEWCASTLE, who also responded to the toast, mentioned that one of the buildings which had formed part of the North-East Coast Exhibition of 1929, on the Town Moor at Newcastle, had been retained and would be utilised as an industrial museum; it was to contain relics of past achievements in the development of metals to the requirements of civilisation. Newcastle, he continued, had benefited by its Stephensons, its Armstrongs and its Parsons, but it had no desire to be satisfied with past achievements, and new industries were developing there. Since he had had a short run on the Diesel-electric unit, built by Messrs. Armstrong, and running on the West Line of the London & North Eastern Railway, he had wondered whether that unit was to be the forerunner of another railway revolution. There was no doubt, however, that Britain would be among the first of the nations to revive its industries, and certainly would survive; he hoped that when that time came the Tyneside would play an important part.

A Dual Mentality.

PROFESSOR HENRY LOUIS, M.A., D.Sc., A.R.S.M., proposing the toast of "The Institute of British Foundrymen," said he accepted the task with very great pleasure, not only because he knew that the toast would meet with a cordial and enthusiastic reception, but also because, although his own experience of foundry work was not a very long one—and he was sorry to say that it had occurred over half a century ago—it had nevertheless left him with a very sincere admiration for the work of the foundrymen. He had realised at a very early stage that a successful foundryman must combine two different and, in some respects, even

opposite mentalities, because the man who prepared the mould must be, and was, an artist, and the man who prepared the metal to pour into the mould must be a scientist. It was rather difficult to combine those two somewhat opposite qualifications. We all knew that the British moulder was a thoroughly skilled man, and he was perhaps one of the few representatives left of the old British handicraftsmanship. He had the artist's trained hand and trained eye for his work. That quality was derived to some extent, of course, by practice, but to a large extent also it must be inborn, and, as we liked to think, inherited from generation to generation.

The foundryman's art was very ancient indeed. Reference had been made to the ancient city of Newcastle, but Newcastle was a mushroom, a growth of yesterday, compared with the foundryman's art. Those who had seen some of the beautifully cast-bronze spearheads of what archæologists called the later Bronze Age would agree that the production of such beautifully cored castings, with their very thin and uniform walls, would tax a good many foundrymen to-day. The inherited skill of hand and eye was important to the foundry trade. Since he had been engaged in the foundry a great deal of manual work had been replaced by machinery. In his day there were no pig-casting machines, no jolt-ramming machines, and so on, but he was convinced that, in spite of the changes that had been made, the skilled hand of the workman was as important to-day as ever it was, and he was fully convinced that our men could hold their own with any others.

For centuries, for æons, foundry work had been concerned entirely with bronze and brass casting. Then, about the 15th century, the art of iron founding was practised. It had originated in Central Europe, but had very soon reached this country, and before very long our ironfounders were able to teach their teachers. It was quite well known in the Middle Ages, throughout what was then the whole civilised world, that the English cast cannon were superior to any other cannon, and all the other nations had come to us for their cannon. Indeed, he had very often wondered whether the great men whose names had been handed down in history, the great sea Captains of Queen Elizabeth's time, did not owe a great deal of their triumph to the obscure Sussex ironfounders who had cast their guns. Be that as it may, he was quite convinced that the foundry industry would continue to flourish, and if the industry continued to flourish, then the Institute would flourish with it. We were living in an age of change. He did not say that we knew very much yet, but we had gained far more knowledge of the constitution of metals than we had possessed half a century ago, and our foundrymen were making full use of that knowledge. The Institute was keeping foundrymen throughout the country in touch with all the most modern developments.

The work of the President, Mr. Stobie—whose name he coupled with the toast—lay more especially in the highly modern branch of steel founding, which had had to develop practically a new technique, certainly within his (Prof. Louis') lifetime. Probably he had had a hand in some of the earliest steel castings ever made in this country, because he had been concerned, about 1880, with the casting of shoes and ties for some of the tin stamps direct from the open-hearth furnace at Landore, and he ventured to think that they were the first steel castings ever made in this country. Mr. Stobie had improved steel practice very greatly, however. He had devised several admirable electric furnaces for melting the steel, and thus was helping forward that branch of the industry.

Finally, Prof. Louis added the opinion that the founding industry would have to change its character somewhat. There was no denying that our heavy industries were in a parlous condition, and he was inclined to think that the future of founding in our country lay in lighter and higher-class work. He had not the slightest doubt, however, that the British foundryman, helped by his Institute, would rise to the occasion whenever necessary and would be able to produce the highest-class work that could be desired.

The President prefaced his response by a further reference to the high-level bridge at Newcastle, mentioned by Col. Ionides. There was a good deal of stress and tension in that bridge, he said, and he believed that within the cast-iron hollow cylinders there were various rods of wrought iron. Coming to the remarks of Prof. Louis, he said that perhaps Prof. Louis had thought—and it was excusable—that the members of the Institute were more concerned with the art of foundry than with the science of foundry. As a matter of fact, however, they were equally concerned with both, for there were within the Institute academic gentleman of great renown, such as Sir Harold Carpenter and Prof. Turner, great industrialists such as Lord Weir and Sir Robert Hadfield, some of the best-known metallurgical works technologists, and, as fully equal brethren, those experienced in the art rather than the science. In all branches there were men who had been apprenticed to the trade and had done the work on the floor, and men with university experience, and some of them had had both floor training and university experience. Therefore, although the Institute's name suggested that it was concerned purely with the artists, it also claimed to embrace within its membership the scientific technologists. The Newcastle Branch had had the pleasure of receiving Papers from Armstrong College, where Prof. Louis was at one time Professor of Mining and Metallurgy.

After some amusing references to events which had occurred during his student days at Sheffield University, Mr. Stobie commented upon the industrial situation, and said that founders were awaiting anxiously the revival of a modicum of shipbuilding and engineering which would enable them to apply the wonderful developments which had been made in their science in recent years. They would then be able to prove that the hopes and aspirations which they expressed on occasions such as this were not empty words.

Mr. W. Scott (Senior Vice-President, Newcastle and District Branch of the I.B.F.), in an amusing speech, proposed the toast of the guests, and extended to them all a hearty welcome. In the course of his remarks he made particular reference to the ladies, and suggested that the Newcastle Branch might invite the ladies to some of its meetings.

Mr. E. J. George, responding, thanked the Institute for its charming hospitality, but added, amid laughter, that he was not sure that he took such delight as did the members of the Institute in the fact that they were scientific. Those who tried to sell to them had a notion that they had got on better when the buyers were less scientific. One would think that science would teach them to know what they wanted, but the more science they acquired the less sure they became that they had what they wanted, or the more positive were they that they had not got it. He was glad that there lingered among them, however, some remnant of the old brigade. One felt so happy when one sent to an individual in a provincial place something which that individual pronounced to be good. However, said Mr. George, he would not criticise his hosts too much, except to suggest that they should not become much more scientific, or it might be impossible for those who supplied them with goods to live with them. (Laughter.)

Though he did not wish to discuss at length the industrial situation, Mr. George reminded the gathering that the tide turned at low tide as well as at high tide; he believed it would turn, and was sure that both the hosts on this occasion and their guests would join together to assist it to turn. We ought not to despair. Not even the most pessimistic, even before dinner, and certainly not after dinner, could be guilty of thinking that the tide would not turn, and turn for the better.

Finally—in a reference to the visit which the members of the Institute were to pay to the Consett Ironworks on the following day, he said he hoped to show them the whole place at work. He would not say how far the work had been saved up—(laughter)—but he pointed out that work had never ceased there for a whole week at a time, and it was something to be able to say that. They had always carried on, even if there were only a shift or two. (Applause.)

Vote of Thanks to Executive Committee.

After the discussion of Papers on Thursday morning, the members again were invited to luncheon at the County Hotel, Neville Street, and before they left for the afternoon visits to works, the President proposed a most hearty vote of thanks to the five knights of the Executive Committee—whose names were mentioned earlier in this report—for the excellent manner in which they had arranged the programme. The smoothness with which the programme had worked indicated how perfect had been their organisation. (Hear, hear.) If foresight were not exercised in the whole of a hundred directions, the odd one-hundredth would spoil the enjoyment of those taking part. The members of the Committee had had to collect the necessary money, the arrangement of the Papers presented had been a big job, the arrangement of works visits had called for diplomacy, and the catering was a matter calling for good taste. He personally thanked the Committee for having almost done his job for him. The Souvenir Booklet which had been produced was a most excellent production. The President took the opportunity to thank the Ladies' Committee, and finally paid a special tribute to Mr. Eckford, the Hon. Secretary, whose work had been prodigious.

Mr. John Cameron (Past-President), seconding, recalled that when engaged in commercial travelling, in his young days, he had visited Newcastle on many occasions, and had found it to be then, as now, one of the most pleasant places to come to. There was a warmth of hospitality and generosity among the people of Newcastle, and the charm of the place had impressed itself very strongly upon him. The present visit had served to emphasise it. Many of the members would recall the high standard which Newcastle had set on the occasion of the annual conference held there in 1924; it was a standard of perfection which had taken the Institute by storm. At that time Mr. Patterson was President, and Mr. Colin Gresty, who was then hon. secretary, and Mrs. Gresty, had done a great deal of work. This year Newcastle had again entertained the Institute magnificently, and the members were indeed grateful.

The vote of thanks was carried with enthusiasm.

Mr. J. W. Eckford (hon. secretary), who was greeted with prolonged applause, responded. He recalled that Mr. R. J. Shaw, who had been hon. treasurer of the Committee, had accepted a post in Coventry during the course of the work, but Mr. Colin Gresty, the chairman of the Committee, had kindly stepped into the breach and had carried out the duties of hon. treasurer as well. Mr. Eckford also expressed thanks to the President, who, at great inconvenience, had attended meetings at which vital decisions had had to be made. The guidance of Mr. Makemson, the Secretary of the Institute, had also been most invaluable.

Finally, Mr. Eckford assured the members that the greatest satisfaction of the Committee was the knowledge that the members of the Institute had enjoyed their visit.

XUM

CIVIC RECEPTION AND DANCE.

On Thursday evening, June 9, members of the Conference and ladies were invited to a reception and dance given in the Old Assembly Rooms by the Lord Mayor and Lady Mayoress of Newcastle-upon-Tyne. In the absence of the Lord Mayor the guests were received by the Deputy Lord Mayor, Councillor Crosby, and the Deputy Lady Mayoress, the Sheriff, Councillor Leadbitter and Mrs. Leadbitter, and the President of the Institute, Mr. Stobie.

The beautiful suite of rooms is an ideal place for a function of this kind, and the wonderful floral decorations added very much to its attractiveness. The guests passed into the large dance hall and the proceedings opened with what to many was a novel function. A troupe of pipers in full Highland costume, lead by a Pipe Major, paraded the hall, and were followed by the Deputy Lord Mayor and Deputy Lady Mayoress, the Sheriff and his wife, the President and Mrs. Stobie, and all the guests fell into the procession, which perambulated back and forward along the great hall. Thus stimulated, the feeling of lukewarmness which sometimes marks such functions at the outset was immediately dissipated, and the guests joined in the dancing enthusiastically.

Later in the evening the pipers again appeared, and members of the troupe gave exhibitions of Highland dancing. Refreshments were served in an adjoining room.

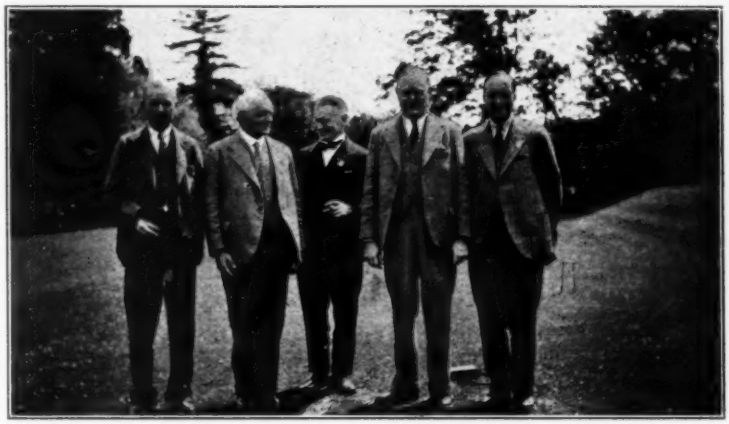
When the guests departed at 12 p.m. it was their unanimous verdict that this was one of the jolliest and most successful functions of its kind that had ever been their privilege to participate in, and there were many expressions of appreciation of the wonderful hospitality of the hosts.

Friday, June 10, the closing day of the Conference, was given over to an excursion by motor coach. About eighty members and ladies left Newcastle by the long straight road to Hexham, which follows the line of the Roman wall and in many places is on the actual site of the wall itself. Glimpses of the wall were seen from time to time, though it is understood that the best preserved portions are further west.

The Roman wall was built by the Emperor Hadrian about A.D. 120, and stretches from Wallsend-on-Tyne to the Solway, a distance of 73½ miles. At each mile a milecastle was built, and at intervals of every four miles was a station to accommodate the garrison.

A halt was made at the camp now known as the "Chesters," or Roman Cilurnum, about 24 miles west of Newcastle. The camp has been fully excavated, and the visitors were able to inspect the barracks for the accommodation of the troops, the remains of the regimental chapel, the strong room and the Commandant's house. There were elaborate systems of drainage which are still well preserved, and the quarters of the Commandant were provided with central heating. Many notable treasures which have been discovered in the excavations have been moved to a nearby museum, which was also inspected. From Chesters the party proceeded to Hexham, where lunch was served at the Hexham Hydro. After lunch, Mr. James Smith, President of the National Ironfounders' Federation, proposed the health of the ladies, which was responded to by Mrs. Victor Stobie.

The journey was then resumed over wild moorland scenery to Otterburn, where another halt was made to permit of inspection of the Old Woollen Mill. The mill was taken over in 1821 by one Wm. Waddell, and produces tweeds of various kinds which are famous all over the world. The only wool which is used in that which is obtained from local sheep bred in the neighbouring Cheviot Hills. Of particular interest were two specimens of hand looms which are still in daily use, producing wonderful examples of modern fabrics. The whole process from the raw wool to the finished article is carried out on the premises, and the mill is a rare example of a self-contained and comprehensive industry whose work is permeated by the spirit of old time craftmanship.



OFFICIALS OF THE INSTITUTE OF BRITISH FOUNDRYMEN AT HEXHAM.
Left to right: Mr. J. Cameron, Past-President; Mr. C. E. Williams, Senior Vice-President; Mr. Victor Stobie, President; Mr. R. W. Stubbs, Junior Vice-President; Mr. T. Makemson, General Secretary.

From Otterburn the journey was continued over the moors to Rothbury, a charming country town and holiday resort well known to Tynesiders. After tea at the County Hotel, Rothbury, the party returned to Newcastle-upon-Tyne by way of Morpeth. On arrival at Newcastle the "good-bye's" and "see you next year's," which are inseparable from all Conferences, took place, and thus ended a very happy and enjoyable last day of a very successful Conference.

LIST OF MEMBERS ATTENDING THE NEWCASTLE CONFERENCE.

J. Affleck, Glasgow; J. B. Allan, Chesterfield; F. Allan, Sunderland; Major J. W. Athey, West Bromwich; W. Auckland, Bolton; V. L. Banks, Newcastle; A. S. Beech, London; James Bell, Newcastle; C. W. Bigg, Derby; Major Bird, Newcastle; F. G. Bird, Newcastle; S. M. Bolishakov, Manchester; L. W. Bolton, Birmingham; B. Brodie, Middlesbrough; C. H. Brown, Gateshead-upon-Tyne; J. N. Burns, London; N. G. Calder, London; J. Cameron (Past-President), Kirkintilloch; A. Campion, Glasgow; E. A. Carlisle, Sheffield; J. C. Charlton, West Hartlepool; H. F. Coggon, Halifax; F. J. Cook (Past-President), Birmingham; W. N. Cook, Manchester; J. H. Cooper, Darlington; W. R. Cooper, Wednesbury; H. Cowen, Falkirk; F. J. Cree, Rochester.

D. Dalrymple, West Bromwich; S. E. Dawson, Newcastle; V. Delport, London; W. E. Dobson, London; J. W. Donaldson, Greenock; W. Donnan, London; J. Durrans, Penistone; P. H. Durrans, Penistone; A. Edwards, Cheltenham; G. Elston, Newcastle; J. English, Falkirk; Dr. A. B. Everest, London; P. Fassotte, Brussels; V. C. Faulkner (Past-President), London; J. Ferguson, South Shields; C. Fontaine, Newport; G. E. France, Halifax; J. W. Frier, Newcastle.

J. W. Gardom, Dunstable; J. Goodfellow, Bishop Auckland; T. Goodwin, Derby; J. G. Gould, Cardiff; P. L. Gould, Cardiff; T. H. Gray, London; C. Gresty, Newcastle; C. Guest, Northampton; J. Guthrie, Middlesbrough; D. W. Hammond, Bradford; A. Harley (Ex-President), Coventry; F. A. Harper, Middlesbrough; A. G. Harrison, Middlesbrough; B. Hird, Newport; J. Hogg, Burnley; W. Holland, Manchester; Lennox Holt, London; H. Howarth, Manchester; R. E. Hoy, Hull; F. Hudson, Kilmarnock; J. E. Hurst, Chesterfield; J. R. Hyde, Newcastle-under-Lyne; J. C. Jones, Workington; C. H. Kain, Braintree; H. W. Kenyon, Accrington; E. G. King, London; H. E. King, Nottingham.

W. B. Lake, J.P. (hon. treasurer), Braintree; Wesley Lambert, C.B.E. (Past-President), London; E. J. Lewis, West Bromwich; G. Lewis, Bilston; J. E. O. Little, Doncaster; A. Logan, Newcastle; E. Longden, Manchester; J. Lowe, Accrington; C. R. Loxton, Leeds; H. Loxton, Leeds; A. R. Lucas, Washington; J. Lucas, Loughborough; G. T. Lunt, Wolverhampton; D. W. Maddock, Wellington; T. Makemson (general secretary), Manchester; J. Masters, Shrewsbury; W. H. Meadowcroft, Burnley; J. E. Mercer, Thornaby; T. R. Middleton, Sheffield; R. A. Miles, Manchester; E. Millington, Derby; T. H. Moorwood, Sheffield; J. Murray, Wellington Quay-upon-Tyne; J. J. McClelland, Newport; F. E. McGrah, Wolverhampton; Dr. P. M. Macnair, London;

F. K. Neath, B.Sc., Keighley; C. A. Otto, Manchester; F. L. Patterson, Newcastle; R. O. Patterson (Past-President), Blaydon-upon-Tyne; A. E. Peace, Derby; J. G. Pearce, Birmingham; C. D. Pollard, Scunthorpe; J. S. G. Primrose, Manchester; W. Redmayne, Spennymoor; C. Renwick, Lincoln; R. J. Richardson, Pontypridd; N. D. Ridsdale, Middlesbrough; H. Roberts, Leeds; W. Robertson, Glasgow; C. H. Robins, Kettering; F. Robson, Newcastle; L. Robson, Sunderland; S. Roe, Oldham; F. W. Rowe, Huddersfield; F. Russell, Worksop; P. A. Russell, Leicester.

H. Schofield, Manchester; W. Scott, Newcastle; F. A. Shirt, Sheffield; J. N. Simm, Monkseaton; Jno. A. Smeeton, London; F. Smith, Chesterfield; Jas. Smith, South Shields; J. E. Smith, Newcastle; R. H. Smith, South Shields; S. E. Smith, Newcastle; W. H. Smith, Birmingham; J. K. Smithson, Middlesbrough; J. A. Smeeton, London; V. Stobie (President), Harrogate; Roy Stubbs (Vice-President), Manchester; A. Sutcliffe, Bolton; E. Sutcliffe, Bolton;

G. W. Taylor, Wolverhampton; T. Titoff, Manchester; T. H. Turner, Doncaster; C. R. vander-Ben, Newcastle; E. H. Wainford, Saltburn; M. Wardle, Manchester; F. J. Wares, Peterborough; W. West, Leyland; J. Wharton, Maryport; T. Wilkinson, Middlesbrough; C. E. Williams (Vice-President), Cardiff; W. Williams, Cardiff; F. P. Wilson (Past-President), Middlesbrough; R. Wilson, Wednesbury; N. F. S. Winter, Halifax; H. Winterton, Glasgow; S. W. Wise, Bradford; D. H. Wood, Birmingham; A S. Worcester, Huddersfield; E. N. Wright, Wolverhampton; E. J. Yates, Stoke-on-Trent.

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Introduction to the Study of Moulding and Casting.*

By J. Pillon.

(French Exchange Paper.)

Foreword.

This thesis is not intended for beginners, and it assumes the possession of a sufficient scientific training and a practical acquaintance with the art of the standard required for admission to the Paris Foundry High School. It does not aim at initiation, its object is higher; it constitutes the first stage of a generalisation which the future will develop.

Moulding in General.

Moulding would be the simplest thing possible if it were possible to mould against the object

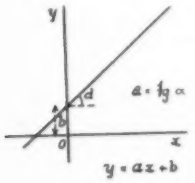


Fig. 1.

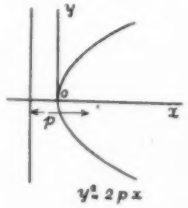
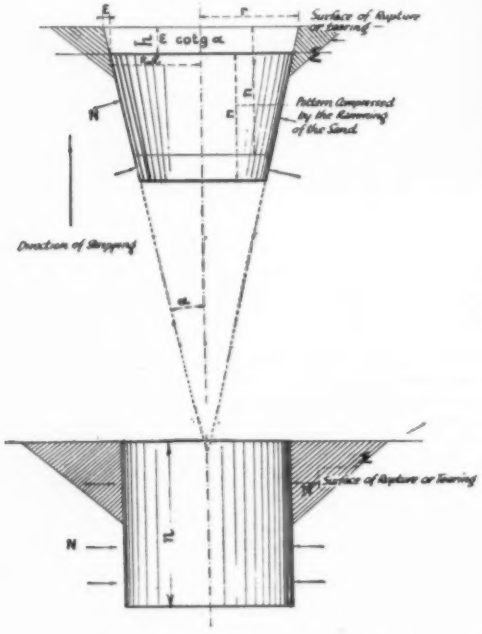


Fig. 2.

to be reproduced, by means of a material sufficiently elastic to be stripped without difficulty from all shapes. This ideal system is only available to the ornamental sculptors who use gelatine for the production of permanent moulds in one piece to receive castings of fine plaster of paris.

Another procedure, dating from remote antiquity, consists in preparing a pattern in moulding wax, surrounding it entirely with fine refractory earth, forming a one-piece mould,



Figs. 3 (upper) and 4 (lower).

followed by heating up to melt the wax and thus obtaining, by the complete destruction of the pattern, a space ready to receive a single bronze casting.

It is not possible to employ similar methods in metallurgy, where the preparation of moulds is

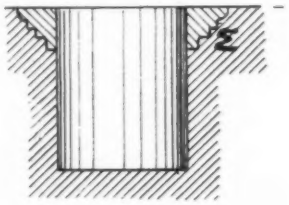


Fig. 5.

subordinated to numerous conditions, as will be shown in the first part of this work.

Mr. J. Pillon.

PART I.—MOULDING AND METALLURGY.

In the whole question of moulding, the problems presented are complex and of two

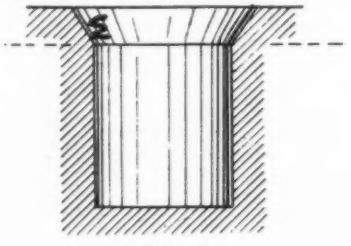


Fig. 6.

different natures: (1) the problems of moulding, properly so-called, and (2) the problems of metallurgy.

Problems of Moulding.

The object sought is the obtaining of a casting exactly similar or at least within close limits to the drawings prepared by the designer. The surfaces of this casting should be free from the faults inherent in the imperfections of the pattern, on the one hand, and the defects in the conception and execution of the mould, on the other. These include draws, scabs, erosion

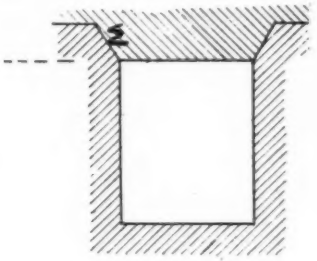


Fig. 7.

due to the flow of the metal, deformations and overloading due to the static and dynamic effects of casting, blow-holes due to the impermeability

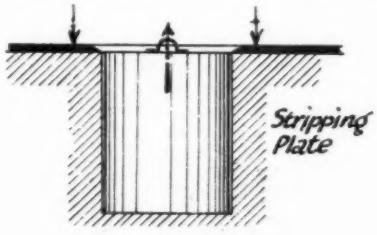


Fig. 8.

of the sand to the gases and steam given off by the damp mould on contact with the metal, cold struts, unsoundness, etc.

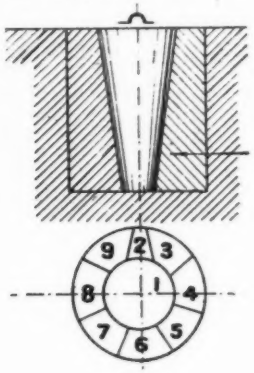


Fig. 9.

Problems of Metallurgy.

The casting should be free from segregation; in other words, it should be chemically homogeneous throughout the whole mass, free from the physical defects which come from aniso-

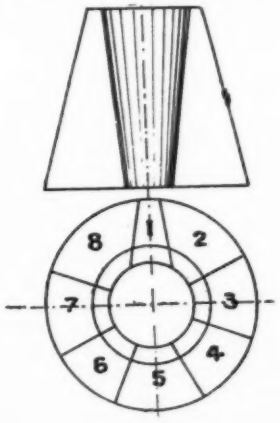


Fig. 10.

* Extracts from the Lectures given at the Foundry High School Paris, by the Author.

thermy, which are internal stresses, cracks, pulls, pipes, etc. It must conform to the conditions imposed by various points of view: specific gravity, hardness, mechanical strength, abrasion, resistance to external agents, magnetic properties, etc. While both classes of problems demand simultaneous solution, the present

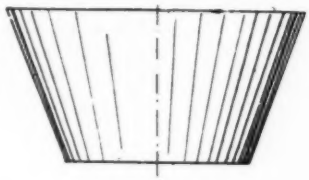


FIG. 11.

analysis will be limited to what is concerned with moulding and casting.

Investigation of the Type of Moulding to Adopt.

It cannot be denied that a casting can be moulded and cast in many ways, and this is

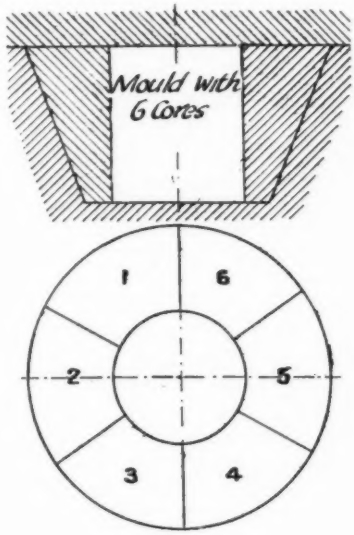


FIG. 12.

perhaps the reason why there has been a total absence of theory until recently. It is, however, possible to guide the moulder in the investigation of the methods of moulding, and to choose amongst all those available, that which will satisfy in the best possible way the conditions imposed by what may be called the *parameters of moulding*. It will be remembered that a parameter is a constant term for each par-

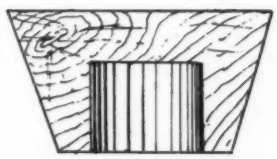


FIG. 13.

ticular case considered, but which can take all possible values from one case to another. This is shown in Figs. 1 and 2. In the equation $y = ax + b$, a and b are parameters which determine one straight line, and only one. In the equation $y^2 = 2px$, p is a parameter which determines one parabola amongst all the others.

In a similar way, the method of moulding may be, among other limitations, dependant on the number of castings to be made. This number will be a parameter which, as a determining factor in the moulding, may lead to the latter being done by strickling, on a pattern plate, with an ordinary pattern, frame pattern, or skeleton pattern, etc.

The parameters of moulding implicitly include those of patternmaking and of casting. In a study more complete than the present one, they ought to be accompanied by those relating to the metallurgical problem, the solution of which

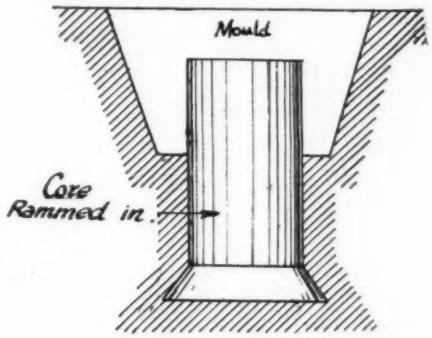


FIG. 14.

is at present engaging the attention of eminent personalities.

In conclusion, it is not a question of establishing rules for the method of the moulding of

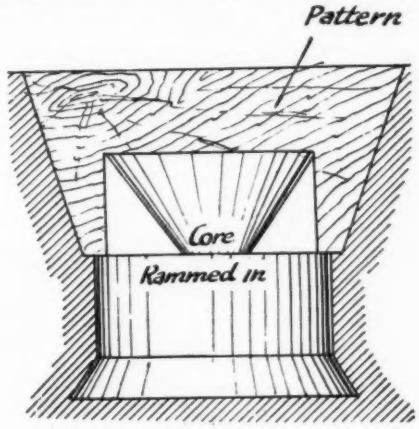


FIG. 15.

a given casting within intangible limits, but, by a methodical examination of the parameters, of deducing the solution or solutions which satisfy the maximum number of them. It might be objected here that what has been cited is only

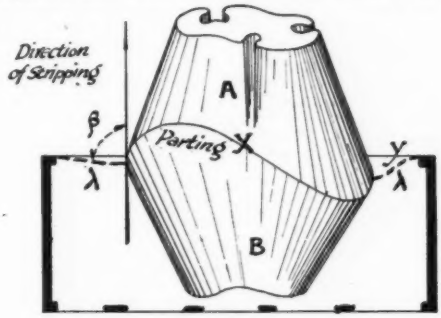


FIG. 16.

what is done, under another name, by those who have acquired what is called the knowledge of the trade, practical experience, skill, etc. The reply to that is easy: It is proposed here to put in a logical form which can be easily assimilated, things which could formerly only be acquired by long years in the shops, which formed one of the greatest obstacles to the scientific and practical evolution of the trade.

The Parameters of Moulding, Properly So-called.

Excluding the metallurgical parameters, the following can be cited for pure moulding:—(1) The selling price (to be kept a minimum); (2) the size of the castings; (3) the importance of the order from the point of view of quantity; (4) the maximum simplicity in moulding; (5) the tolerances imposed; (6) the delivery period imposed; (7) the soundness of the metal and ease

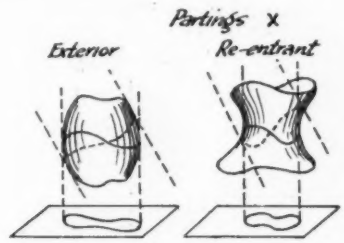


FIG. 17.

of machining; (8) the skill of the operatives; and (9) the materials available, etc.

The highly-developed study of moulding at the Paris Foundry High School is nothing other

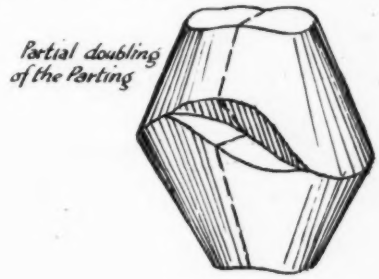


FIG. 18.

than the presentation, too long to describe here, of the conditions imposed by each of the parameters of the above incomplete list in order to determine the best method of moulding (*i.e.*, in

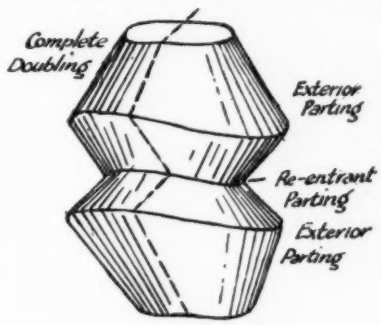


FIG. 19.

boxes from patterns set horizontally or on end, with running planned in regard to gates, running green-sand or dry-sand moulding, etc.).

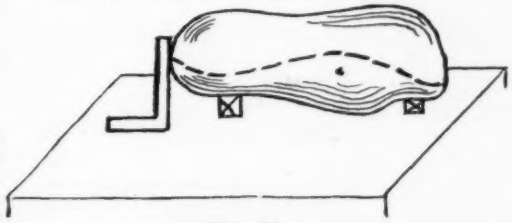


FIG. 20.

The Pattern.

Apart from all classification, the pattern is the tool which, materialising the shape of the casting, that is to be buried in the plastic material forming the mould, in order to imprint therein the complementary shape, allowing for

core prints, machining allowances, shrinkage and taper, which are the four parameters of pattern-making. The first three are imposed by the shape of the casting, the machining to be done, and, finally, the changes in the physical state on cooling after casting.

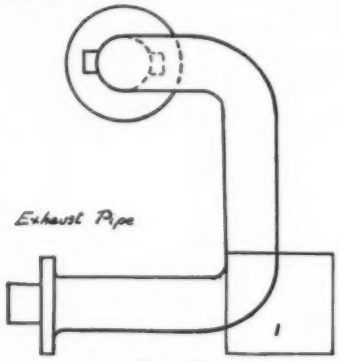


Fig. 21.

Stripping.

The last parameter—taper—which it seems useful to define geometrically, determines the greater or lesser ease of the delivery of the pattern from the sand. Absolute taper is that represented by the surface of a cone with point

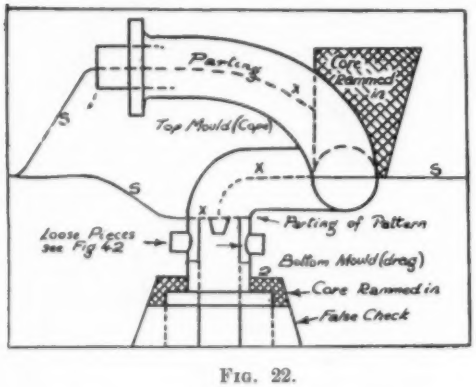


Fig. 22.

downwards, it causes a tearing force at the beginning of the stripping, which is a function of the pressure due to ramming (N) and of the

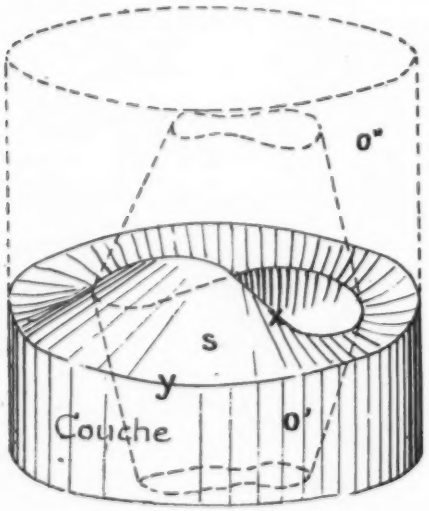


Fig. 24.

coefficient of friction (f). This tearing effort continues during a certain portion of the stripping up to the moment when contact ceases. If ϵ is the elastic reduction in length of the radius in each straight section as the result of the ramming, then, obviously

$h = \epsilon \cot \alpha$ (Fig. 3).

Taking a cylinder instead of a cone, friction on delivery continues during the whole period of the latter as is shown in Fig. 4.

Relative taper is that represented by the surface of this cylinder, which is the extreme limit of the possibilities of natural stripping. In all cases there is tearing of the sand along a surface of rupture ϵ. At least, if the precaution has not been taken in the first place of reducing friction, f, by polishing the pattern, and, in the second place, of employing one of the following:—(1) Rapping or preliminary vibration; (2) pro-

Fig. 23.

filing the pattern, according to the plane of rupture (Figs. 5, 6, 7); (3) use of a stripping plate (Fig. 8); (4) making the pattern to take apart so that it can be removed in pieces (Figs. 9 and 10); (5) making the mould to take apart (Figs. 11 and 12); and (6) building in (Figs. 13, 14 and 15).

It is obvious that the reverse taper, which cannot always be avoided (locally or altogether), can be represented geometrically by the surface of a cone with the base at the bottom. Easy stripping can, however, be attained by the methods 4, 5 and 6 indicated above.

Method of Using the Pattern.

In order that the complementary imprints in the mould shall be strippable, it is obvious that they must only enclose the pattern in accordance with the conditions of absolute and relative taper. These elements are bounded by a line

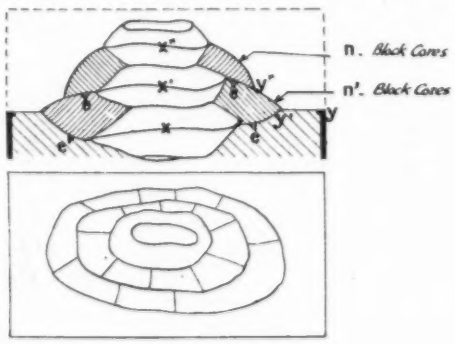
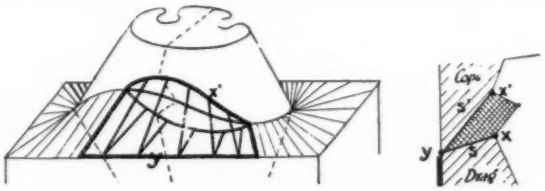


Fig. 29.

called the joint, where, usually, the taper changes in direction, called the parting. This line is mostly crooked, and the surface of the joint is developed by a varying line λ passing from the flat edge γ of the box on one side to the parting X on the other. This joint surface is conoidal and ought only to include parts in absolute taper, with the angle β as open as possible, in order to attain the effects indicated with regard to stripping. In what follows, this surface will be designated by the letter S and that which is moulded against it by − S.

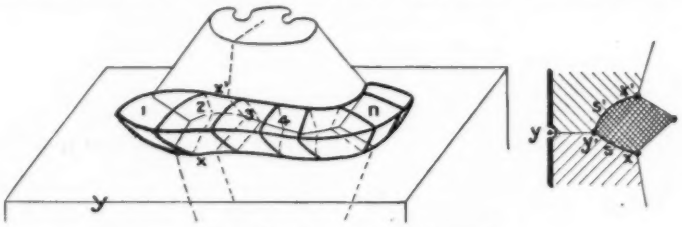
Investigation of the Joint Lines or Partings.

This investigation is subordinate to the setting of the method of moulding which is determined by the preceding analysis—the parameters of moulding. In the simplest case the parting is single and completely visible, when it consists of one intersection as shown in Fig. 16. If the surface is curved the parting appears as a contour fixed by the enclosing cylinder, the generating lines of which are parallel to the direction of stripping as shown in Fig. 17.



Figs. 25 (left) and 26 (right).

Often the parting is locally as in Fig. 18, or totally as in Fig. 19 divided into two, it becomes multiple and constitutes what is called the system of partings for the mould under consideration. The investigation of the system of partings is relatively easy on a pattern such as that shown in Fig. 20, by means of a surface plate and square, but it becomes often very difficult if it has to be made from drawings. This demands great care and a skill in reading drawings, which can only come from a perfect



Figs. 27 (left) and 28 (right).

knowledge of descriptive geometry (Figs. 21, 22 and 23).

Note.—There are cases where, instead of a system of partings, recourse is had to a system of joints; for example, by using separate moulds or moulds composed of cores.

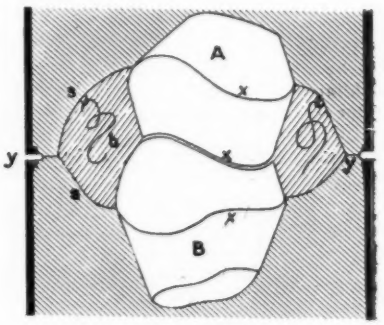


Fig. 30.

Hand Moulding as a Function of the System of Partings.

(1)—*Parting in one plane.*—The pattern is cut along the parting and moulding is done on a board, which acts as a bed.

(2)—*Parting consists of a single crooked surface.*—The pattern as a whole is placed in a bed of sand or in plaster of paris, which takes the place of the board in the preceding case (Fig. 24). The speed of moulding can be doubled by using two patterns and two complementary plaster beds.

(To be continued.)

Some Aspects of Oil Engine Foundry Practice.*

By Herbert E. Beardshaw.

The cast-iron and foundry practice of which it is proposed to speak, is that which may be taken as representative of the general practice obtaining in a "works foundry." By this it is desired to distinguish between the small jobbing foundry and the mass-production repetition foundry. In this (the works foundry) each piece of work has to be handled and treated according to its own characteristics, and whilst there are occasionally some hundreds ordered from one pattern, the quantities generally do not permit of the conveyor or mass-production methods.

The status of ironfounding in the engineering world is acknowledged, and the craftsmen attached thereto are now recognised as exponents of a "fine art." The skill and craftsmanship necessary to bring into being some of the products of the designers' efforts compel every respect. This raises a point that should be stressed on every possible occasion, namely, that of design.

Design.

Whenever a new design is projected the foundry should be consulted. Much valuable time, and consequently money, can be saved if some of the primary founding difficulties are eliminated, or at any rate alleviated, at the design stage. By this it is not desired that every job must be so arranged that it is free from difficulties, a state, of course, that is impossible of attainment, but only rarely is the foundry considered. The designer may have a knowledge of foundry requirements, but his is a general knowledge, and not the specialised knowledge required to foresee some founding difficulties. The foundry is usually handed the pattern with the order—so many off—and pounds are expended in attempts to overcome what may be almost unsurmountable difficulties in their desire to turn out a "good job," when a slight alteration in the original design, an alteration in no way affecting the general design, would have saved this expenditure.

These remarks apply more particularly to the more intricate and consequently more costly type of casting, such as castings similar to the cylinder block and cylinder head of the modern oil engine.

Materials.

It is essential in modern foundry practice to have some knowledge of the chemical and physical characteristics of the materials used in the manufacture of high-grade castings, and all iron should be examined and graded according to these characteristics. The policy of grading by fracture is in the author's opinion rather out of date, as this is a policy fraught with danger, since irons of absolutely opposed characteristics can present almost identical fractures.

The chief objection to grading and working by analysis in the past has been the lack of facilities to carry out this work. All foundries cannot, or say they cannot, afford to operate a laboratory. This is a mistaken idea, when it is making high-duty iron. The systematic examination of the raw material and of the finished product are essentials. But, even where laboratory facilities are not available, it must be remembered that all reputable manufacturers of pig-iron will supply the products to a specified analysis, and will supply certificated analysis of a particular consignment. The effects of the principal constituents of cast iron are fairly widely known among foundrymen generally, and it is proposed to confine any remarks in this phase to the silicon in particular.

By adopting some form of silicon control founders of high-duty work will have a fairly safe foundation, and all work in the foundry with which the author is concerned is controlled on this basis. Simply stated, the fundamental idea is this: that apparently the maximum strength properties are obtained when the iron is on the border line of chill (the various metallurgical considerations it is not proposed to deal with). This is also the condition required to give the maximum commercially-machinable hardness—another very desirable feature. Assuming, therefore, that the other constituents are kept within certain specified limits and conditions are standardised, the relationship between the silicon content and the hardness can be determined, and, as the hardness varies also with the thickness of section the relationship between the silicon percentage and the section thickness for any value of hardness can be determined.

From personal experience, and excluding alloy irons for the moment, the maximum hardness that can be efficiently handed is 230 Brinell, and on this assumption and using a value between 220 and 230 for various jobs, the relationship between section and hardness can be determined. This, by the way, is definitely confirmed by a prominent firm of iron manufacturers in the Midlands, the almost identical graphs being published in their catalogues. It will be realised that a step too far causes some considerable trouble, because if castings become unmachinable a great deal of scrap will result, but careful control, however, will enable the work to be produced very satisfactorily and to within close limits.

There is a modification to be considered, apart from any foregoing considerations. The cooling conditions have considerable effect on these irons, and difficulties may arise should these values be used on castings with very efficient cooling conditions, *i.e.*, large $\frac{\text{surface area}}{\text{volume}}$ ratio. Where the type of castings is not conducive to very rapid cooling, the silicon content may be lowered even further. Details as to the meaning will be given at a later stage, when individual jobs are considered. Such, then, is a general statement as to the method of control adopted, and the value and importance of organised examination will be realised. It would be quite useless to attempt such control without analysis.

Sand.

This very important feature of the iron foundry's work is frequently neglected, and, in the past, very little attention has been paid to its examination. The "old school" were very efficient examiners by rubbing the sand between finger and thumb and squeezing a handful, but, unfortunately, one cannot take readings on that basis, and some form of examination—a form that gives standard readings—should be established. There are many more castings lost owing to unsuitable or defective moulding sand than is generally realised, and a constant source of trouble is that founders are timid of casting hot, owing to the effect of hot metal on the mould. In the author's opinion, it is a mistaken policy to penalise the iron for the benefit of the mould. If the mould will not stand the iron, then improve the mould. The advantages of casting hot outweigh the disadvantages, and the situation may be summed up in the statement that "hot running covers a multitude of sins and errors."

To go into details with regard to the examination of sands is beyond this work, the matter has already been very practically dealt with by Smalley, Holmes, Skerl and Buchanan and others, but the point to remember is that without some standard of examination, good conditions cannot be reproduced. On any one day! as foundrymen well know, everything goes well, there are no dirty or scabbed castings, no trapped gas, etc., but can those conditions be reproduced the next day, or a week or a month hence? It is not improbable without organised examination. The principal characteristics effecting its use in the moulding and core shops are:—(*a*) Grain size, (*b*) mechanical strength, (*c*) permeability, (*d*) chemical analysis and (*e*) refractoriness.

The first three can be examined in a very simple manner; for grain size, successive sieving may be adopted, using standard sizes, if it is necessary to compare with other examinations, but for a purely internal examination, a succession of sieves of the order of 50, 80 100, 140 and 170 meshes per sq. in. will give a good idea as to the grain size. As for mechanical strength, there have been numerous Papers, embodying this feature, presented to the Institute, and members will find their difficulties all cleared for them. A simple permeability test embodies a standard core (standard quantity, standard ramming, etc.) and simple aspiration apparatus. Measurements of time and quantity of air give a basis of comparison. One point that should be mentioned, is that sand should not be "milled" unless, of course, it is desired to break down the larger grains. This question has been very fully dealt with, and probably needs little comment here. The foregoing indicated the necessity for systematic examination of materials, which examination should be extended to all factors affecting the actual production, but as the examination of materials is a field for several specialised Papers, the author proposes to pass immediately to the castings, with which this Paper is primarily concerned.

Flywheels.

The flywheels required for the high-speed compression-ignition engine are very simple castings; a plain disc wheel, say, 22 in. overall dia., rim section, say, 6 in. by 4 in. to 2 in. They are required to run at any speed from 250 r.p.m. to 2,000 r.p.m. Perhaps it sounds too simple for worry, but when the stipulation is made that, after machining, the wheel must not be more than 2 ozs. out of balance, the matter becomes rather more difficult. These wheels weigh anything between 2 and 5 cwts., dependent upon the type, and, taking a 4-cwt. wheel, for example, it will be seen that this accuracy of balance is of the order of 1 in 3,500 (*i.e.*, 2 ozs. in 7,200 ozs.). Another way of looking at this is, that should the specific gravity of that material vary between 7.30 and 7.31 across the wheel, then it is rejected.

These castings are made in the following manner. They are cast plate-side down, and run by the rim. The mould is jolt-rammed from a pattern. The location of the runners is very important. They must be diametrically opposite to each other, and to ensure that the runners are vertical a deep locating-hole in the pattern receives the runner-peg when the top part is being rammed. A deep bush is set to include both runners and the whole mould set up carefully (to a level) on girders in the floor. These precautions may seem ridiculous in a foundry, but from bitter experience it has been found that it is the only way in which one can ensure a good job. The whole casting is supplied by one head of metal; the two runners are the same diameter. The job is placed in one plane, the result being that, within the limits of the job, the conditions are ensuring the same amount of metal passing the two runners. The author can assert that this is necessary. For example, if a wheel is badly out, and, fortunately, it is one that has been rushed through to the machines and the head and runners are still available, they are found and the trouble revealed. The moulder, in blacking his bush,

* A Paper read before the Lancashire Branch of the Institute of British Foundrymen, Mr. E. Flower presiding.

had allowed a good trickle to run down the gate, with the result that the effective area of that runner was reduced, the volume entering was reduced, and the wheel unbalanced. [This runner was available for inspection.]

These jobs are cast in very low-silicon iron, and another feature is the time of casting (this being an indirect measurement of the temperature). Low-silicon iron is more difficult to cast and to enable it to be handled with facility it should be tapped very hot. With ordinary runners, the wheel is usually unbalanced due to contractions. The author has found that the best results are obtained by casting hot with runners of such a size that one can almost imagine the wheel being built up as it is being poured; that is, they are comparatively small runners and enable the wheel to be "just" cast. Considerable experimental work has been done in determining the correct size of runners.

With low-silicon iron and using very small runners there is always the danger of the runners "building up," that is, the outer skin solidifying, and this solidification becomes progressive until the runners are completely made up, and if castings are made under these conditions they are obviously short run. To determine correct sizes, a series of experiments have been conducted, or are still being conducted or less, but considerable work has been done with the low-carbon irons, of which something will be said in the appropriate section.

The material is such that separately-cast test-pieces, cast $\frac{3}{8}$ in. dia. and machined down to 0.564 in. dia., *i.e.*, $\frac{1}{4}$ in. sq. in. give consistent results between 18 to 20 tons per sq. in., the maximum reached is 22.3 tons per sq. in. The transverse strength of a bar 12 in. by 1 in. by 1 in. is 4,000 lbs. These figures are being surpassed by special-alloy irons and irons produced by special devices, but the point is that those cited are produced by an ordinary cupola with no additions of steel to the cupola mixing, and as such they can be produced by any founder.

Further, test-bars cut from the rim of the flywheel show 14 to 15 tons per sq. in., which in the author's opinion is good. Incidentally the whole point of obtaining these wheels as near perfectly balanced as possible is not the outstanding consideration; from calculation they are perfectly safe to well over 5,000 r.p.m. The main factor is wear on the end bearing of the engine. The closeness of the limits cannot be stressed too heavily. Several rejected wheels, unbalanced to the order of, say, 6 to 8 ozs. in 4 cwts., have been broken at the unblanced part, and only the expert eye could detect the immediate cause, the faintest of "draws." But there are no risers, but a series of "whistlers are provided along each side of the mould at the top of the casting. These slot runners act as a filter for scum, etc., and provide a rapid, yet gentle, means of filling the mould. The whistlers are from the crankcase face of the cylinder blocks, and here, again, considerable experimental work has been done in determining the correct size. Should they be too small the metal does not flush through when it rises to that head and gas is invariably trapped. Should they be too large, then one has difficulty in casting the job, owing to the fact that the metal will not solidify in the small passages, and consequently it becomes "run out."

The stopwatch is again used as a measure of the fluidity of the iron, and immediately a certain time is exceeded in the casting of a block, the ladle is returned for further supplies of hot metal.

The material of which these castings are made is a very important point. The desired features have just been outlined, but with such a casting, with section varrying from $\frac{3}{16}$ in. to about $\frac{5}{8}$ in., a difficult problem is set. The appearance of the fracture is shown in Fig. 3. The casting has to be machined in most parts, and this feature is the basic consideration, that is, the hardness of

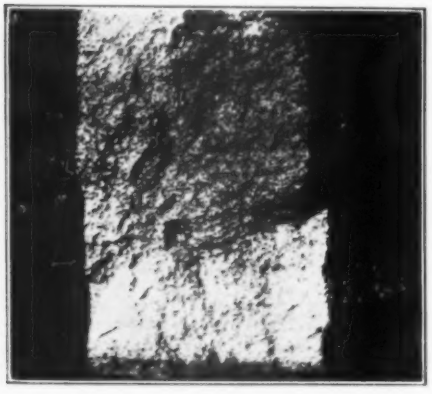


Fig. 1.—Section of High-Speed Compression Ignition Engine. Flywheel run showing Evenness of Grain-Size.

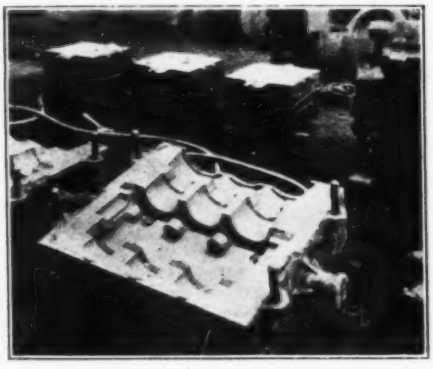


Fig. 2.—High-Speed Compression Ignition Engine. Half Mould. Cylinder Block, showing Runners, etc.

Fig. 3.—Section through Cylinder Block, showing $\frac{3}{16}$-in. Jacket and $\frac{3}{8}$-in. Cylinder Wall.

would perhaps be the better term, on a simple hydrostatic basis. A standard "bush" is set up with standard runners of varying sizes, and temperature time and weight measurements are recorded. At the outset the job appeared fairly simple and the lack of available data was to be wondered at, but it is developing into a very complex problem, the solution of which is not yet complete. This is assuming one grade of iron and knowing the temperature (within limits) the time taken to cast a wheel are valuable indices of its solidity.

A point to be mentioned, however, is the fitting of "stoppers." It is essential that no iron trickles past the stoppers whilst the bush is being filled. This at least is one definite conclusion, the reason being that not being that with a "full flush" of metal, the trickle solidifies and forms an excellent basis for the building-up process in the "gate," and an unbalanced wheel results. Similarly, care must be exercised with regard to the moulding and closing—a "run out" of very small dimensions is invariably fatal and the wheel concerned is badly out of balance. The introduction of the stop-watch to the foundry is probably new to some members, but it is a very valuable tool throughout, as no doubt will be realised later.

Before leaving the flywheels, it should be mentioned, of course, that it is a dry-sand job, even the bush going into the stove with the top part, and everything being kept warm. The composition is of the following order:—T.C. 3.0 to 3.2, Si 0.8 to 1.0, Mn 0.8, S 0.06 and P 0.2 per cent.

it must be remembered that the influence of that drawn spot is extending probably half-way round the rim, and therein lies the trouble. As has been pointed out, the slightest variation of the specific gravity across the wheel causes this out-of-balance effect. The fracture of the flywheel rim is shown in Fig. 1.

Cylinder Heads and Blocks.

These castings present a different problem. The requirements are that they be made in a high-grade iron; of high-tensile and transverse strength; maximum hardness at the parts subjected to wear, and capable of being commercially machined at all parts of the casting. Considering once more the high-speed combustion-ignition engine; the cylinder blocks are cast in one, two and three bores. The working part of the cylinder is an integral part of the casting and not a separate liner. They are cast on-end with the cylinder skirt to the top. The mould is split in the vertical plane and is jolt-rammed. The runner bush and runners are part of the pattern, ensuring uniformity in this connection. The two halves of the mould are rammed and finished, then stoved for the night, being taken out just prior to casting for the cores to be inserted and closed. Their appearance at this stage is shown in Fig. 2. They weigh approximately $\frac{1}{2}$ cwt. to 1 cwt.

The filling of the mould is accomplished by means of a series of fine slot runners for each bore, the metal being introduced down the bore.

the thinnest section must not exceed 230 Brinell. Under these circumstances the thicker sections such as the bore will suffer, and will not be at the maximum hardness, for as is well known, the hardness figure will vary inversely as some function of the section thickness.

To overcome this, denseners are used at that part of the bore that is subjected to the heaviest wear. The size, shape and volume of these denseners varies according to the conditions and is the subject of research in individual cases, but it can be stated generally that they are divided around the circumference of the bore core and inserted by keying in on this core at the appropriate place. In this manner a casting that is machinable at its thinnest sections, and yet hard wearing in the thickest, is obtained.

Cylinder Heads or Breeches.

These are, again, intricate castings, as they are required to be of high-grade iron and perfectly sound. Their appearance is shown in Fig. 4. The moulds for these castings are jolt-rammed and the mould is filled by means of two sets of "spray runners" (this term is used for want of a better one) one at each end. They are subjected to the same drying as the cylinders.

There are numerous cores and intricate passages to be traversed by the metal, and here, again, it is found that it is necessary to work with extremely hot metal and cast to stopwatch control. In this case the reason for the timing is as follows:—Should the filling of the mould take

more than the standard time, it is interpreted as indicating that the metal is not sufficiently fluid to fulfil all the conditions required. It may run the casting, but, owing to the fact that there are contained in the mould some almost totally-enclosed cores, some studs, and several denseners, there is usually some trapped gas. This, of course, does not reveal itself until machining has taken place, and it has been found that it is much more economical to take all castings over a certain time-limit and scrap them in the foundry. It requires courage, but should there be six doubtful castings sent to the machine shop and only two are scrapped, it has usually cost more to machine those two than to scrap the six in the foundry. When the time is correct, it is taken to mean that the metal is sufficiently fluid to deal with such conditions, and such has been proved to be the case. Obviously, as the time begins to increase, the ladle is returned, the spare iron poured into pigs, and a fresh supply obtained.

They are cast "face up," that is, the face that is machined and fitted to the cylinder block (and incidentally the joint takes the full explosion pressure of the heavy-oil engine) is to the top. This pressure on 4¼ dia. is approximately 46 tons. Chills are used in places, and many founders will criticise this policy, but there are various reasons for this practice, and it is justified by the measure of success. On numerous occasions valuable information has been obtained by filling a mould that has not been closed and observing the behaviour of the metal, mould and cores. Data as to position of vents and so forth have been obtained in this manner.

Another point concerns the studs used. There is a limit to size and weight to enable production of good castings, and should this limit be exceeded, the fact is revealed on water-test and by the machine shop by bad castings. One case occurred a short time ago, when several castings showed signs of trouble adjoining the studs. An inquiry was held immediately, and it was soon found that the particular size had been ordered through non-foundry channels, with the result that they were ordered on an inexperienced description. The weight was 70 per cent. in excess, and endless trouble was caused.

The inspection department at the firm with which the author is connected would break the morale of any ordinary founder in a few weeks. It is necessary that every casting produced should be free from apparent blemish or defect. By apparent is meant capable of being found in the course of an inspection of the most rigorous nature. The cylinders and breeches (shown in Fig. 5) are cast in similar metal, the composition of which is of the order of:—T.C., 3.0 to 3.3; Si, 1.7 to 1.9; Mn, 0.8; S, 0.05, and P, 0.3 to 0.4 per cent.; and test-pieces cast separately give 16 to 18 tons per sq. in. This is no mean performance when one considers that some parts of the castings are only $\frac{3}{16}$ in. thick. One particular occurrence with regard to these jobs may be of interest. Several cylinder heads were being scrapped on account of gas-holes in a certain face of the casting, the gas apparently not finding its way to the vents in the main core. The usual sequence of events took place. The moulder was blamed, but he protested that it was the coremaker's fault. The latter, however, demonstrated that he had used a maximum number of vents, and suggested the metal was not hot enough. Everything was tried; even the "binder" people were called in, but they thought conditions were ideal. A simple test was tried as a result of a series of guesses. A core was made up, baked, etc., and after sealing all vents except one, which one was connected to a supply of low-pressure compressed air, the whole was immersed in a glass tank containing water. The air left the core at the corners and a few isolated spots. A similar core was tested in the same manner with the exception that it was "rubbed" all over; that is, the outer skin was taken off, before immersion, and the result was astounding; air poured from every part of that core. Obviously something in the surface was sealing the core, and the use of the resinous powder used to dust the core boxes was discontinued, and the trouble disappeared. This example has been cited as an indication of what very simple tests can do.

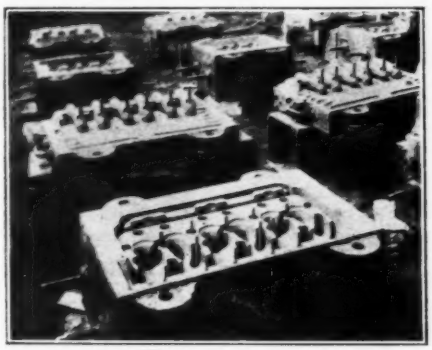


FIG. 4.—HIGH-SPEED COMPRESSION IGNITION ENGINE. MOULD, CORED UP, FOR BREECH OF 3-CYLINDER BLOCK, SHOWING RUNNERS, ETC.

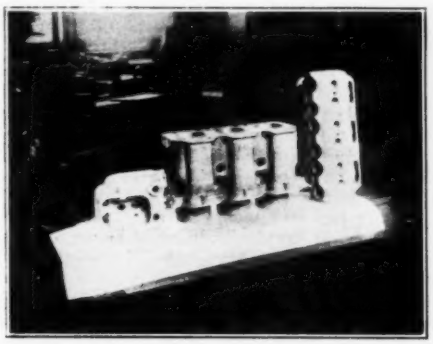


FIG. 5.—HIGH-SPEED COMPRESSION IGNITION ENGINE. SINGLE-CYLINDER BREECH CASTING; 3-CYLINDER BLOCK CASTING; 3-CYLINDER BREECH CASTING.

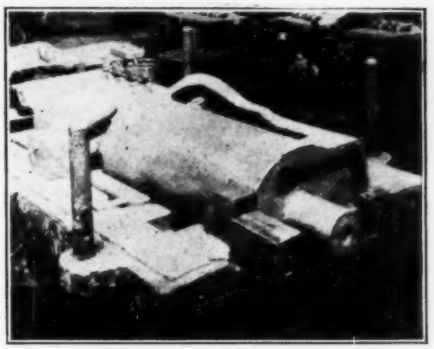


FIG. 6.—CYLINDER MOULD, LARGER TYPE OF OIL ENGINE, SHOWING MAIN RUNNER AND SUBSIDIARY RUNNER.

Sprayers and other Small Castings.

Turning for a moment to small castings such as fuel-sprayer bodies. The latter are quite small, but again the qualifying clauses cause some thought. It has to withstand 3,000 lbs. per sq. in. in paraffin, and severe mechanical stresses at various parts of the casting. This job has been made in various mixtures, from straight irons, alloy irons, proprietary irons of all types, but it has been found that the best results are obtained by casting it on the side with an iron of the following composition: T.C., 3.2; Si, 1.6; Mn, 0.8; S, 0.06, and P, 0.4 to 0.5 per cent. The lower portion of the machined part (that has been lapped) is the bed of a spindle carrying the valve and has to be fitted so as to carry an oil pressure of 2,500 lbs. per sq. in.

There are other types of pump bodies, and the usual practice is to cast in as low a silicon as the particular size will stand. Even then it is necessary to chill the whole core of the job, usually by means of a solid mild-steel chill, that subsequently is drilled out.

Crankcases.—These are a very thin and light structure. The general section thickness is of the order of $\frac{3}{16}$ in. They are run at the bottom and a subsidiary runner opened after the mould is about two-thirds full. This is done to liven up what might have been rather dead metal, after having traversed extremely thin and tortuous sections. Low-silicon iron is not used on these jobs. Immediately after casting, the bush is opened and drained into a pig and all runners freed, an essential precaution in view of the spider-like character of the structure. Cores are freed twenty minutes after casting.

Exhaust Pipes.—These are the usual founder's nightmare, as they have a general thickness of between $\frac{5}{32}$ and $\frac{3}{16}$ in. The only troubles with this type of casting appear to be to run them successfully and in such material as is capable of easy machining. It will be noted that they are run along practically the whole length by what might almost be termed "flash runners"—a very successful procedure.

Larger Castings.

Leaving the smaller castings and turning to the slightly larger jobs, such as cylinders for the modern cold-starting semi-Diesel engine, of medium powers, say up to 50 h.p. per cylinder, the author has been asked to mention this case as likely to be of interest. These cylinders, of which again the bore is an integral part of the casting, weigh anything up to half-ton, and again are cast spigot up. The usual way of running these would probably be a down-runner feeding the mould from the bottom and rising on the spigot. But why have the extra weight of sand and larger boxes to accommodate the runner, as there is plenty of room for a runner down the centre of the bore core, as is shown in Fig. 6.

This is provided, and at the bottom it opens into four radial ingates to the mould, and considerable success was maintained until the silicon was lowered to give greater hardness. Then trouble occurred because the first metal to enter the mould was considerably chilled by the time that it has to run the bosses, etc., near the top of the mould, and if they were successfully run they were invariably white and unmachinable. To overcome this a subsidiary runner was cut from the same bush, through to the liner, part of the casting, and at a certain moment this gate is opened and a stream of hot metal enters the rising body of metal at the top.

It is essential that this stream enters at the correct moment, too early an entry means that certain port cores take the full force of the drop (perhaps 3 ft.) and too late an entry does not help. Again the stop watch is used. All grates and runners are standard and after the initial determination of the item of filling up to the port cores, all that is required is an indication at the correct moment to the operative holding the second stopper. Many practical founders may disagree with this method of running, but in founding the merits or demerits of any methods may be measured by the degree of success attained, and they are still run in this manner.

The analysis of the material for this type of work is T.C., 3.2 to 3.3; Si, 1.0; Mn, 0.8; S, 0.06; and P, below 0.2 per cent. the general thickness of section is about 1.0 in. This silicon content seems to be regarded by many people as being rather low and it has been suggested to the author that the general limits are too low, but the results obtained indicate that such is not the case, for rarely is the boundary line overstepped.

Breeches.—The breech for the so-called "semi-Diesel" type of engine is an intricate water-cooled job, and must be capable of withstanding very high pressures. This type of job, shown in Fig. 7, is usually cast in rather lower silicon than that indicated by general practice. The reason is that it is such a compact, self-contained job, with very inefficient cooling conditions. Here, too, denseners are used in certain parts.

In connection with this type of work, together with the flywheels (small disc and straight cylinder liners) considerable work has been done with low-carbon irons, and the range covered will extend down to 2.1 per cent. total carbon and 0.75 per cent. silicon, and the author has found that this pig can be melted by cupola and cast quite successfully. The first point to mention is, that, apparently, whatever the total carbon value into the cupola, the finished casting has a carbon content of between 3.1 and 3.4. It

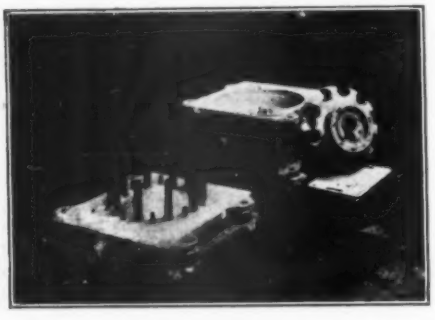


FIG. 7.—BREECH FOR LARGER TYPE OF OIL ENGINE.

is realised that this depends to some extent on the cupola practice, but generally it is necessary considerably to increase the coke charges for 100 per cent. charges of such iron in order to reach a higher degree of superheat. The question might be asked them what is the advantage claimed for the low carbon iron. The graphite precipitated is apparently of a different form, that is, a more finely-divided form. The seed-carbon theory is very much discussed, and, frankly, the author does not propose to reopen this discussion. The main issue from the founder's point of view is that he obtains a closer-grained iron, a hard, yet machinable, iron and an iron with improved physical characteristics generally. But without special means of melting this iron trouble is likely to occur. By "special means" the author indicates the necessity to be in a position to superheat the molten iron considerably and also to cast exceedingly hot.

In the first place, when using this iron under ordinary melting conditions and casting, say, an ordinary liner or a pipe cast on-end. When the metal splashes at the base of the mould the small globules solidify, and the temperature of the incoming iron is such that it cannot completely redissolve this shot. It sounds rather incredible, but it is practical experience. Secondly, in the past a great deal more of the gases generated in a mould escape by means of the metal than is generally realised, and when one comes to use an iron without any "life" (*i.e.*, it is exceedingly hot and fluid but will not remain in this state very long), the trouble is soon encountered. Two such liners cast under exactly similar conditions, except that one has an original-mixture analysis of T.C., 3.2; Si, 1.0; Mn, 0.8; S, 0.06, and P, 0.2 per cent., and the other T.C., 2.2; Si, 1.0; Mn, 0.8; S, 0.06, and P, 0.2 per cent. The first was perfect, whilst the second revealed a number of gas holes on machining. This is not a coincidence because it has repeated itself on numerous occasions.

There is no doubt that the low-carbon irons yield better castings when the conditions are suitable, but ordinary melting apparatus and ordinary foundry practice apparently will not allow of these conditions, and whilst research is still being carried out, the author has returned to more amenable regions so far as total-carbon content is concerned. The various effects of different combinations of T.C. and Si have been presented to the Institute, particularly by Fletcher, and the discussion of such a subject is beyond this Paper.

Casting Stresses.

Another phase of ironfounding about which little is known is that concerned with the initial stresses in castings, and the author takes this opportunity of giving the general results of some research into this point in which he collaborated some time ago. Consider armed flywheels, such as are used on the single-cylinder horizontal slow-speed oil engines, as a suitable subject for examination. First, the theoretical considerations were thoroughly examined and a series of equations deduced combining the various functions effecting this matter (this is much too lengthy and extremely mathematically involved to be considered here), and a scheme of operations was decided upon.

A number of armed wheels (all arms radial, *i.e.*, not curved) were obtained, sizes varying between 4 ft. dia. and 7 ft. dia., with rim sections of 15 to 40 sq. in.; they are not very large wheels, but are suitable to the purpose. The wheels were stored at an even temperature, together with standard reference bars and micrometers, for several days, careful records of the temperature being taken. Measurements were then taken of the diameter of the wheel (on 6 diameters for 12 readings making 1 and 7 the same). It must be mentioned that the wheels were perfectly standard and had been machined in the standard manner. The measurements were taken so that alternative measurements were on arm centres and on the spaces.

These wheels were now removed to the machine shop and the arms cut practically through, close to the boss, by means of a thin cutter. The cutting operations were stopped before going finally through in order not to damage the tool on the release of the strains. After removal to the measuring room, the boss was knocked out by hammer blow. This released all strains in the wheel, and records of the change in dimensions were immediately obtained. Further measurements were taken day by day, and careful control of the temperature of the wheels and measuring devices was undertaken.

This operation was repeated for a number of wheels of various sizes—actually either six or seven.

At the same time, test-pieces were cut from the arms in order to obtain important fundamental data, such as the tensile strength, transverse and compressive strength values.

Results Noted.

It will be noted from Fig. 8 that, in the first case, the arms were in tension and the rim in compression, and in the second case the original strains in the arms were compressed and in the rim tension. The others were in various states. These dimensions were checked at intervals up to twelve months, and no alteration was noted apart from one that has been stood on edge; this had assumed a very slightly elliptical form, owing presumably to its own weight. In spite of the variety of results, three of the five shown conformed very closely to the theoretical considerations. The stresses found were of the order of 1,000 to 2,000 lbs. per sq. in. There was nothing very conclusive about the job, but it enabled the amendment of the design of wheels to give any required state after castings, within very wide limits, of course. Similar work has been carried out on the smaller plate type flywheels, but definite results have not as yet been obtained. The methods of measurement are such that no strains can be measured.

Testing and Examination of Castings and Test-Pieces.

Very careful examination of all deliveries is an essential feature of modern foundry practice. As the author has remarked before, it is much cheaper to scrap in the foundry than in the machine shop. Water testing should be carried out both before and after machining, in order to enable rapid corrections to be made in whatever phase of the manufacture is determined to be an error. The castings have also to be examined for hard spots, blow-holes and other defects. With regard to the first named, a very useful tool is the percussion type of hardness tester, the type wherein a standard bar transmits a blow to a hardened steel ball and thence to the casting under examination. It is not claimed that this gives absolute values of Brinell hardness, but it provides a very definite standard of

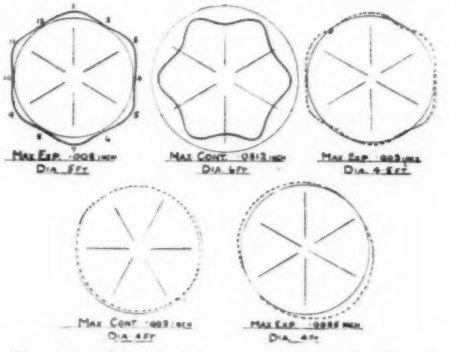


FIG. 8.—GRAPHS SHOWING SHAPES TAKEN UP BY FLYWHEELS AFTER RELEASE OF CASTING STRAINS.

comparison, and incidentally saves the determination of hard spots by the ruining of expensive tools.

The author has seen considerable useful work done with hardened steel point in the detection of gas holes and bad spots in the casting, all machined faces being subjected to an examination of this nature. Another important development of modern inspection methods is the use of jigs in the foundry inspection department. Cheap reproductions of the machine-shop jigs, used in conjunction with suitable gauges, enable the detection of such things as displaced cores. It seems very childish for a casting to be, say, a week undergoing expensive machining operations and then to be rejected because of the fact that a small cored-hole will not clean up.

Testing of Materials.

This, in the author's opinion, is a very important phase of foundry work, and one which is frequently neglected. Ironfounders themselves contribute to their undoing by constant subscription to the idea that cast iron is a very poor material. They do this unwittingly, it is true, but nevertheless it is done.

With some founders the only time that they evince an interest in the physical quality of cast iron is when some outside authority or customer calls for tests. They then prepare test-pieces, sometimes with an appalling lack of knowledge as to the requirements and conditions, send the test-pieces to some authority to be tested, and hope for the best. If it gets through the normal 11 to 12 tons per sq. in. tensile requirement all is satisfactory. If not, they invent some excuses and try again. The point is, they cannot say to a customer "You may

have this job in 18-, 16-, 14- or 10-ton iron" and enable him to specify exactly as to his requirements. Instead, the designer, in making the design, postulates from a handbook reference giving 8 tons per sq. in. plus a safety factor, say, 4-1, an actual limit of stress accruing of 2 tons per sq. in. The result is a much heavier and clumsier job than is strictly necessary. The founder, in his turn, sits back and smugly thinks that his castings never fail in service. Obviously they do not, or did not, but in these days, when weight reduction is vital and aluminium and its alloys are a very serious competitor, they will soon fail—to find a market.

In this connection the author desires to mention that in the capacity of an independent authority, examining material for other people, generally in the presence of their customer or a member of some inspecting authority, he has handled some cast iron that really made him ashamed to test it. Cast iron that could not carry 11 tons per sq. in. Frankly, he does not know how they manage it. Such people are contributing to their own downfall, and in the natural trend of things they should fade out of existence. An example may be drawn from the requirements of a national buying authority, which issued a specification covering various types of work, up to 18 tons per sq. in. But this 18 tons must have been too much, for the next year's specification was down to 16 tons per sq. in., and it is regrettable to note that it has been further sub-divided and reduced in parts since. The point is that, in order to bring about this amendment, numerous founders must have failed, and failed very considerably, to reach the requirements, and let a great opportunity to improve the status of cast iron pass by.*

The founder and the engineer are torn between several schools of thought. Some desire the test-pieces cast on the job, some wish for them cast separately; others want this size and shape, and others want something entirely different. Such a state is another relic of the "bad old days," when everyone pleased himself and set his own standards. This is now being rectified, due largely to the work of the B.C.I.R.A. and the B.S.I. in standardising the conditions under which test-pieces must be cast.

The author would like here to interpose his personal opinion on this question, an opinion backed by considerable experience in the examination of test-pieces and of cast iron. He prefers, and for his own part insists on, separately-cast test-pieces, cast from the same material as the job and under *standardised conditions of moulding, cooling, etc.* Note the *standardised* conditions. His opponents of the other school immediately retort that these test-bars are not representative of the casting. He agrees with them; it was never intended to represent the casting, but it is representative of the material of the casting when subjected to certain conditions, standardised conditions, and the only conditions under which it is fair to compare test-pieces, either with others of their class or with a specification. This, of course, is considering one class of casting, and he wishes to make it clear that he is not an advocate of one set of conditions for a small cylinder and for a large flywheel. In this case there would be standardised sizes and conditions up to certain weight and section limits.

Some people prefer machined test-pieces, others unmachined. The machined test-piece advocates stress that it is unfair to give the test-pieces the benefit of what is known as the "skin effect," whilst the piece of work supposed to be represented is machined all over. This is quite a reasonable argument, but one can take a test-piece, and, by machining it, increase its stress-carrying capacity, which upsets that argument. The point being that a good cut will remove the skin effect almost completely, but a "skim" over simply removes all the minute cracks, and distensions that are present in the skin of the casting, and so, by removal of these cracks increase its resistance to fracture. The way out of this is, again, standardisation of conditions.

In the actual testing there are some points to be considered; quite a number of the poor results are due in one way to inefficient testing. This is a very usual failing. The provision for holding the test-piece is rigid, and the bar is rigidly gripped in the machine. Now it will be appreciated that it only needs to be loaded obliquely to a very slight extent, and the breaking load is reduced owing to the fact that the load is not applied along the axis. It is, in fact, being subjected to eccentric loading, and very few thousandths of an inch vitiate the reading, and, what is more, that malalignment is not the same in all cases; it varies each test-piece, thus ruining the test from an absolute and a comparative point of view. Very little addition to the testing apparatus (such as a universal joint of the simplest nature at each end) will allow of truly axial loading within fairly narrow limits.

The tensile and the transverse tests are usually the only tests required on cast iron. The Izod test has not been found to be of much value. Some years ago, in connection with one of the prominent research laboratories the author conducted a great number of tests to attempt to relate the tensile and impact tests, but at that time, in spite of hundreds of tests, nothing definite could be obtained, and it would appear from the work of such as Pearce, etc., that there is not any definite relationship.

In conclusion, the author desires to stress the point that he is considering only the commercial examination such as could be carried out by any small foundry, and does not propose to explore the vast realms opened up by the academic examination of this material. These, then, are some of the points of view of a person who is neither a foundryman nor an academical metallurgist. The author desires to point out that his advent into the foundry world was not in any way organised. The initial idea was purely chemistry, but in order to check the value of the chemical examinations considerable time had to be spent in the foundry, and the more time spent in this manner the less confidence was placed in the old methods of preparation for the actual production of castings, with the result that now the whole of the charging operations are personally checked and keen observations taken in the foundry in an attempt to control these factors and to collect data concerning these and other variables.

As a result the author knows well how open he is to criticism, but in an endeavour to forestall some of that criticism he desires to point out that he is aware the variables that he thinks are being controlled and these are a very small percentage of the whole. One obvious criticism would be on the lines, "What is the use of taking all this trouble when one is at the mercy of the cupola?" Obviously it does seem a little ridiculous when one cannot tell what is happening to one's efforts at this stage. But by standardising all that is susceptible to standardisation or control, both before and after the cupola and controlling the cupola practice, there is a much better chance of obtaining consistent results than if the whole series of operations were conducted in a haphazard manner from day to day.

It is hardly necessary to emphasise the careful charging of the cupola. All pig-iron is broken to 9-in. lengths and the scrap is also broken to corresponding dimensions. Care is taken to charge as level as possible, and, in short, everything is due to assist in the standardisation of the product. Various great authorities on cast iron and foundry practice have from time to time made a statement to the effect that "foundry practice can never be an exact science." Perhaps they are right, and, as numerous authorities have been proved to be in the past, perhaps they are wrong, but all parts and sections of foundry practice that can be technically controlled should be so.

Some founders of the whole school do not like it, but they should realise that all the technical control is merely a co-ordination of their ideas and experience in some recordable form, and most developments are directly traceable to this experience. Or again, another criticism may be—everything is dependent upon temperature measurement. The difficulties of this are realised. The author is fortunate inasmuch as he has been working in conjunction with some enthusiasts in Germany on an immersion type of optical pyrometer and one that works under as near ideal black-body conditions as is possible. With this experience he has been able to measure the difference between other cheaper and more easily-handled forms of temperature measurement and correct them accordingly.

Finally, the author desires to acknowledge his indebtedness to the directors of Messrs. L. Gardner & Sons, Limited, for permission to use any information obtained at their works and to acknowledge the valuable co-operation and assistance that is always placed at his disposal by Mr. H. E. Hunter and Mr. Swann, of the same firm.

* This statement requires considerable elaboration before acceptation, as weight of casting and available plant are cardinal factors.—EDITOR.

Random Shots.

(*Concluded from page* 378.)

When Charles II was hard up we suggested a cast-iron, instead of a gold currency, which would have made him independent of Louis XIV's loans. Unfortunately, while our managing director was up in town arranging this contract, he was involved in an affair with Nell Gwyn and left London in a hurry. He later made the excuse that he was afraid of the Great Plague which was then raging through London.

The famous Vicar of Bray was our London Representative for a long time, so our business did not suffer by the many political changes of this period.

Oliver Cromwell gave us a large contract for supplying "Ironsides," whatever they were. Later our junior partner distinguished himself by carrying the good news of Queen Anne's death from Aix to Ghent. No one believed him.

When German George muscled in our chairman did not know whether to support him or Bonny Prince Charlie, so he put a bob each way on Charlie and lost. This was a bad time for us. Our chairman made things worse by saying that the Prince Regent was no gentleman. (He was, of course, the First Gentleman in Europe.) The depression only ended when our iron foundry distinguished itself by turning out the famous Iron Duke.

In Queen Victoria's glorious reign we advanced from strength to strength, and by a mistake of the Office of Works we actually got the contract for supplying all the glass for the Crystal Palace. Our junior partner of this time (a young dog) was the first man to wear Dundreary whiskers. The Queen, on seeing him, said "We are not amused!" It is whispered that both Melbourne and Palmerston took an interest in our business (a substantial one, in return for which we got many government contracts).

In the reign of Edward VII I myself remember the Kaiser spying around our works, disguised as a Boy Scout. We did very well out of the Great War. All our directors were elevated to the peerage in connection with supplying pikes and halberds to the Air Force. It was later found that a mistake had been made, and that we should have supplied iron castings, but it was too late then and the damage was done. In any case we had done our best.

Our vast profits soon disappeared in those riotous post-war years, and so we have decided to make brass.—Yours, etc.,

DUBB & PARSONS, LIMITED,
Brass Founders.

This Week's News in Brief.

Trade Talk.

A new bridge over the Foryd at Rhyl, built by Messrs. Dorman, Long & Company, Limited, of Middlesbrough, was opened last week.

The Electrical Switchgear & Equipment Company has acquired a factory at Banbury, is installing machinery, and hopes to be ready for output in six weeks.

Two locomotives with tenders, built by Messrs. Robert Stephenson & Company, Limited, of Darlington, are being shipped this week from Middlesbrough for the Ottoman Railway Company.

A company has been formed with works at Prescot, Lancashire, under the title of British Copper Refiners, Limited, with the object of producing high-conductivity copper for electrical purposes. The new company is closely associated with British Insulated Cables, Limited.

A contract for sandblasting and "Nust"-ing the steelwork at Manor House Station, on the Cockfosters extension of the Piccadilly Railway, has been given to the Nor-Rust Liquid Lead Company, Limited, Iddesleigh House, Caxton Street, London, S.W.1, by the London Underground Railways.

General Steel Castings Association.—A circular has been issued on behalf of the General Steel Castings Association asking the owners of all carbon steel casting works in England, Scotland and Wales whether they would be prepared to sell their works for dismontling in order to get rid of redundant capacity.

The Clyde District Committee of the United Patternmakers' Association has issued instructions for the withdrawal of their members from the Holm Foundry, Cathcart, Glasgow, of Messrs. G. & J. Weir, Limited, in sympathy with the moulders who ceased work a week ago. The number of additional men affected is sixteen.

The Yorkshire Association of the Institution of Civil Engineers made an inspection of the Staveley Coal & Iron Company's works, near Chesterfield, on June 15. After spending the morning at the Devonshire Works, the visitors were entertained to luncheon by the company, and the afternoon was devoted to an inspection of the new sand-spun pipe plant.

Three new open-hearth furnaces are to be erected for the English Steel Corporation, Limited, at Sheffield, by Messrs. G. P. Wincott, Limited, also of Sheffield, which, we are advised, will all be equipped with Leeds & Northrup patented automatic reversing equipment. This equipment operates on a temperature-difference control, which eliminates reversing on a time cycle.

The contents of two factories are being transported from the Continent to the North of England by way of the train ferry and the L.N.E.R. Wool textile machinery, weighing 15,000 tons, is on the way from Roubaix, France, to Mossley, Lancashire. The contents of another factory, consisting of 50 tons of waxed-paper-making machinery, are to be transported from Holland to Knutsford.

Latest returns reveal a substantial improvement in the South Wales tinplate industry. The production of tin and black plates in the first quarter of this year totalled 229,000 tons, against 158,600 tons in the corresponding quarter last year. Pig-iron production totalled over 100,000 tons in the same quarter, representing an increase of 45 per cent. compared with the first quarter of last year. The output of steel ingots and castings amounted to 374,000 tons, an increase of nearly 25 per cent.

Messrs. Yarrow & Company, Limited, Scotstoun, Glasgow, have just completed the Flotilla Leader "Dubrovnik" for the Yugoslav Navy. The vessel is 371 ft. overall with a breadth of 35 ft., and the hull has been designed with a view to securing the greatest possible combination of strength, speed and manœuvrability, together with seagoing qualities. The vessel has twin screws, and is propelled by geared turbines. She has completed an exhaustive series of trials on the Clyde, when a speed of 37 knots was attained over a six-hour period with a remarkably small fuel consumption.

The directors of the Electric Furnace Company, Limited, in their annual report, state that electric-furnace installations having a total power of over 21,000 kw. were on order at the end of the financial year (March 31). In the Sheffield district a new steel-melting shop has been built and equipped with high-frequency furnaces. At the Ford Motor Company's new works at Dagenham furnaces of more than 10,000-kw. capacity are approaching completion. Although business in France has been very depressed, important orders have been received from other countries, including one from India for brass-melting equipment. Among plant of special technical interest ordered during the year are mentioned 20-ton arc furnaces of 5,000 and 6,000 kw. and 5-ton high-frequency installations of 1,250-kw. input. The 5-ton high-frequency furnace is the largest unit of this type yet constructed.

Personal.

Major Richard Miles has resigned his position of general manager of the ironworks of Messrs. Newton, Chambers & Company, Limited, of Thorncliffe, Sheffield, and local director of that firm, and accepted a position as director and general manager of Messrs. Head, Wrightson & Company, Limited, of Stockton-on-Tees.

Mr. A. V. Gravely has been appointed general manager of the wire works of Messrs. Dorman, Long & Company, Limited, Middlesbrough, in succession to the late Mr. F. W. Todd. Mr. Gravely was for many years a member of the commercial staff of the company, and later general manager of the firm's constructional works at Sydney and Melbourne.

Mr. Malcolm Blair, who has held the position of general manager of Messrs. Head, Wrightson & Company, Limited, of Thornaby-on-Tees, for 21 years and director for 12 years, is resigning his position as general manager in July next, but will retain his position as a part-time acting director of Messrs. Head, Wrightson & Company and its subsidiary companies.

Wills.

M'Phail, William Cruickshanks, brass-founder, Glasgow £8,349

Barker, Herbert, of Morecambe, iron-founder and engineer £13,290

Obituary.

The death occurred at Doune, Perthshire, on June 14, of Mr. Thomas A. Greer, who was for over 50 years associated with the Fairfield Shipbuilding & Engineering Company, Limited, Glasgow. He was for many years secretary of the company, and only retired in March last year. Mr. Greer belonged to a family well known in Glasgow industrial circles; his brother, Mr. H. A. Greer, is a member of council of the Institute of Metals and a cousin of Lord Justice Greer.

Company Reports.

R. Hood Haggie & Son, Limited.—Interim dividend of 5 per cent.

John Brown & Company, Limited.—Net profit, £2,654; credit balance carried forward, £13,185.

Falkirk Iron Company, Limited.—Brought in, £41,247; dividend for year, £4,863; depreciation, £3,365; carried forward, £42,178.

Guest, Keen & Nettlefolds, Limited.—Net profit, £201,569; brought in, £347,489; first preference dividend, £91,000; carried forward, £458,058.

Edgar Allen & Company, Limited.—Loss on working, £17,008; profit on exchange, £7,480; written off loose tools, etc., £3,038; loss for year, £11,053; debit balance carried forward, £43,150.

Electric Furnace Company, Limited.—Net profit, £9,306; brought in, £1,179; dividend of 7 per cent. on the cumulative preferred ordinary shares, £5,600; to reserve, £3,000; carried forward, £1,885.

James Keith & Blackman Company, Limited.—Available balance, after providing for preference dividend, depreciation, etc., £19,519; dividend on the ordinary shares of 5 per cent., £7,500; carried forward, £12,019.

Iron and Steel Import Duties.

EXTENSION OF INITIAL PERIOD.

The Import Duties Advisory Committee gives notice that it has under consideration the question of recommending that the existing temporary additional duty on iron and steel products, which expires on July 25 next, should be continued for a further limited period. The present duty was imposed for an initial period of three months by the Additional Import Duties (No. 1) Order, 1932, and certain additions and amendments were recently made by the Additional Import Duties (No. 2) Order, 1932.

In its first report, the Committee contemplated that the temporary duty would be continued, subject to any necessary variations, until it was in a position to submit proposals of a more permanent character, and it is now clear that it will not be in a position to submit such proposals before the expiration of the current period of three months.

Any representations which interested parties may desire to make in regard to extending the period of the existing temporary tariff should be addressed in writing to the secretary, Import Duties Advisory Committee, Caxton House (West Block), Tothill Street, Westminster, S.W.1, and should be received at that address not later than Tuesday, June 28.

Income Tax and Losses Carried Forward.

The Finance Bill has now passed through the House of Commons, and it is worth while noting that it contains a concession to firms who have been going through bad times which may be very valuable. Six years ago, when the three years' average was abolished, it was provided that losses could be carried forward for six years against any future profits for income-tax purposes. It was assumed that this meant against profits for the next six years, but it was so worded in the Finance Act that it was interpreted to mean against the next six years' assessments, the first of which was on the loss concerned, so that only five possible years' profits remained. At the same time, depreciation allowances, which are allowances made in consideration of wear and tear of machinery, etc., and are made equally in a year of loss as in a year of profit, were to be deducted first from any future profits, before past trading losses were considered. The Federation of British Industries made representations in connection with these two points on the occasion of more than one past Budget and in connection with this year's Budget. It will be understood that until this year sufficient time had not run for the point to arise, and it is gratifying to note, therefore, that before the first occasion when the hardship could be felt, the Federation's representations have persuaded the Government to reverse the practice with regard to depreciation. Firms which have been going through hard times will find this a very substantial concession, as depreciation allowances may be carried forward without any time limit. The concession in the Finance Act lays it down that, in effect, losses shall be set off against future profits first and depreciation allowances, which are not subject to a time limit, dealt with subsequently. In all ordinary cases this is very much to the advantage of the taxpayer. In one exceptional case, which arises where a private business has been transformed into a limited company, owing to a technicality it would not be to the advantage of the taxpayer if this were done, and the Finance Act recognises this by allowing the old practice to continue in this case.

Iron and Steel Output in May.

The National Federation of Iron and Steel Manufacturers report that there were 69 furnaces in blast at the end of May, the same number as at the beginning of the month, three furnaces having ceased operations and three having gone into blast. The production of pig-iron in May amounted to 315,300 tons, compared with 316,900 in April and 346,500 tons in May, 1931. Production included 75,400 tons of hematite, 128,000 tons of basic, 92,600 tons of foundry, and 11,300 tons of forge iron.

The output of steel ingots and castings in May amounted to 416,900 tons, compared with 433,300 in April and 435,100 tons in May, 1931.

XUM

PIG IRON

Manufacturers of FOUNDRY, BASIC and HEMATITE qualities. Delivery from stock.
Booklet giving analyses, etc., will be sent on request.
DORMAN LONG & COMPANY LTD.,(Incorporating BOLCKOW VAUGHAN & Co., Ltd.,)MIDDLESBROUGH

DORMAN LONG

FOR REFINED PIG OF THE HIGHEST QUALITY
CONSIDER THE APPLICATIONS OF THE SODA ASH PROCESS
It produces

PIG IRON for grey iron castings which are tough, easy to machine, close grained and of consistent quality.
WHITE and MOTTLED PIG for malleable castings, having a shorter annealing time and improved physical properties.
REFINED ALLOY PIG with better yields on the alloying elements.

The Soda Ash process is economical and easy to apply.
It enables the manufacturer to control the sulphur content of the metal within close limits and to reduce it by 45-80%. It removes gaseous and non-metallic inclusions, and refines the graphite.
It permits of the use of the lowest grade scrap and high sulphur coke.

Full details and information will be supplied by
IMPERIAL CHEMICAL INDUSTRIES LTD.
IMPERIAL CHEMICAL HOUSE, LONDON, S.W.1
Sales Offices: Belfast, Birmingham, Bradford, Bristol, Dublin, Glasgow, Leicester, Liverpool, London, Manchester, Newcastle-on-Tyne
ICI
C.N. 21

Raw Material Markets.

Although conditions now are generally admitted to be far more favourable to a recovery in trade, business in the iron and steel markets has as yet shown little improvement. The efforts being made to rationalise the iron and steel industry, and the further protection extended to pig-iron and small castings has led to a more optimistic feeling, but the widespread depression on the consuming side and the presence of untouched stocks of foreign material in this country, are acting against any early improvement. There has, however, been an increase in the number of forward inquiries circulating in some sections.

Pig-Iron.

MIDDLESBROUGH.—At the moment, sales are almost entirely for immediate delivery, but forward inquiries are showing a slight increase. Exports remain at a very low level, owing to the increasing difficulties encountered in transacting overseas business. Subject to special concessions in Scotland, the fixed home prices of Cleveland iron are:—No. 1 foundry, 61s.; No. 3 G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s. per ton, f.o.t.

The East Coast hematite market remains steady, the most satisfactory feature being the partial regaining of the South Wales market, where cheap foreign iron had long been favoured. Mixed numbers are quoted at 62s. 6d., below which the merchants are not inclined to go. There are no new developments in the West Coast hematite market, trade remaining limited both on home and export account. Bessemer mixed numbers continue at 66s. per ton at works.

LANCASHIRE.—Deliveries of foundry iron in this area are maintained at a steady level. Exports of textile machinery continue to show improvement. The jobbing foundries and the heavy engineering branches are badly in need of orders, although the light-castings industry maintains its position. Several more odd orders for delivery over the next two or three months have been received. For delivery to users in the Manchester district, prices of Midland makes—Derbyshire and Staffordshire—remain at 67s. per ton, North-East Coast No. 3 also at around 67s., Northamptonshire at 65s. 6d., Derbyshire forge at 62s., Scottish foundry at around 86s. 6d., and West Coast hematite at about 81s., with Indian iron at about 75s. per ton.

MIDLANDS.—Orders for foundry iron are scarce, while deliveries of iron contracted for are diminishing rather than increasing, as many of the foundries in the Midlands are working short time. The duty on foreign iron will not affect this district, as little had come in for some time. Northants No. 3 is at 62s. 6d. and North Staffordshire, Derbyshire and Lincolnshire No. 3 at 66s., delivered to Birmingham and Black Country stations. Cleveland No. 3 is available at 66s.

SCOTLAND.—Work is very irregular at the foundries, many of which, owing to the approach of the annual holidays, are endeavouring to reduce their stocks. Little new buying has been reported. The official minimum of 69s. 6d. for Scottish No. 3 foundry remains in force, with an extra of 2s. 6d. per ton for No. 1, there being a poor demand both locally and over the border. No. 3 Middlesbrough is obtainable at 55s. 6d. per ton f.o.t. Falkirk, and Northamptonshire iron, high in silicon, can be got at as low as 53s. at Falkirk, with ordinary No. 3 at 1s. more.

Coke.

Activity in the foundry coke market remains on a very limited scale, forward business of any magnitude being little mentioned. Best Durham coke averages about 37s. 6d. per ton delivered in the Birmingham district, with other grades at 2s. 6d. less. The quotations for Welsh coke vary according to analysis and tonnage and are anything between 30s. and 45s. per ton, delivered Birmingham.

Steel.

Orders for finished steel have shown no improvement, but prices in general are maintained, although there is keen competition in uncontrolled products. Business in heavy structural material, plates, etc., is very scarce. Most of the specifications received are also on the small side, so that frequent changes of rolls have to be made. Tinplates remain a steady market, but there has been no recovery in galvanised sheets. Home makers of semis report a slightly better demand, but the total business passing is not very large, as many consumers are still in possession of large stocks.

Scrap.

The demand for cast-iron scrap in the Cleveland market remains on a very limited basis. Heavy cast iron is at 36s. and heavy machinery quality in handy pieces at 37s., while light castings are at no more than 33s. per ton. The Midland iron-founders are also experiencing a slack time, and little business in scrap iron is being done. Good supplies of material are available in South Wales, where heavy cast iron in large pieces and furnace sizes is plentiful at 38s. to 40s. Good cast-iron machinery scrap for foundry purposes has a limited demand at about 42s. 6d. The position at the Scottish foundries offers little improvement, and the scrap iron market is correspondingly slack. Machinery cast iron in pieces not exceeding 1 cwt. is offered at 45s. to 47s. 6d., and for ordinary cast-iron scrap to the same specification 41s. 3d. to 42s. 6d. is asked.

Metals.

Copper.—The standard market has shown a gradual recovery during the past week, mainly owing to the stronger tone shown by the dollar. More interest has been taken in standard and electro grades, both here and in America, and the position is slightly stronger. The exporters are still offering customs metal at 5.50 cents c.i.f. Europe, and outside interests are now not going much below this level.

Closing quotations :—

Cash.—Thursday, £27 6s. 3d. to £27 7s. 6d.; Friday, £27 16s. 3d. to £27 17s. 6d.; Monday, £28 2s. 6d. to £28 5s.; Tuesday, £27 11s. 3d. to £27 12s. 6d.; Wednesday, £27 11s. 3d. to £27 13s. 9d.

Three Months.—Thursday, £27 to £27 2s. 6d.; Friday, £27 10s. to £27 11s. 3d.; Monday, £27 15s. to £27 17s. 6d.; Tuesday, £27 6s. 3d. to £27 7s. 6d.; Wednesday, £27 6s. 3d. to £27 7s. 6d.

Tin.—This metal, in conjunction with copper, responded to the weakness in sterling and prices strengthened appreciably. Consumption in this country remains steady, the most promising sign for the future being the sudden expansion in the demand for Welsh tinplates, particularly for early delivery. Continental consumers have also shown a moderate interest.

Official closing prices :—

Cash.—Thursday, £112 to £112 5s.; Friday, £114 to £114 5s.; Monday, £114 10s. to £114 15s.; Tuesday, £113 15s. to £114; Wednesday, £116 5s. to £116 10s.

Three Months. — Thursday, £114 10s. to £114 12s. 6d.; Friday, £116 7s. 6d. to £116 12s. 6d.; Monday, £117 to £117 5s.; Tuesday, £116 to £116 5s.; Wednesday, £118 10s. to £118 15s.

Spelter.—There has been no outstanding feature of the spelter market, the promising start made by the Lausanne Conference, however, helping towards a more optimistic tone. The consumptive demand has shown no improvement, but all stocks are firmly held, and the position shows no weakness.

Daily fluctuations :—

Ordinary. — Thursday, £11 11s. 3d.; Friday, £11 16s. 3d.; Monday, £11 12s. 6d.; Tuesday, £11 11s. 3d.; Wednesday, £11 10s.

Lead.—Although the recovery in prices brought more inquiries from consumers, any buying is on cautious lines. However, it is known that the majority of consuming works are working on very small stocks, and this metal will be one of the first to recover once the general industrial position takes a turn for the better.

The week's prices have been :—

Soft Foreign (Prompt). — Thursday, £9 5s.; Friday, £9 15s.; Monday, £9 13s. 9d.; Tuesday, £9 12s. 6d.; Wednesday, £9 13s. 9d.

Students' Corner.

(*Continued from page* 376.)

Q.—Can information be gained by reference to types of cupolas other than standard?

Answer Continued.

(6) The balanced-blast cupola.—This cupola has been evolved and developed by the British Cast Iron Association. In its operation it contains and embodies features that are apparently quite new. The melting is controlled by a balanced-blast arrangement, such having been ascertained by research work and experiment. Its future bids fair to becoming a recognised economic melting unit. The blast entering the main tuyeres is directed downwards from the air belt, and other auxiliary smaller tuyeres are situate higher up and pass direct from the wind belt into the cupola shaft; these, we understand, are all under control. The chief features are the formation and control of the gases CO and CO_2, converging them at the most economic limit at the melting zone proper.

Some of the advantages claimed are—20 to 25 per cent. saving in fuel consumption, a reduction in loss of various elements in the charge, and an improvement in the quality and uniformity of the melted metal.

Q.—Are there in existence furnaces capable of competing with the cupola?

A.—There are other types of circular melting units which differ from the ordinary cupola type, namely, the Brackelsberg, Sesci and Sklenar furnaces. These furnaces do the melting in the horizontal position, are rotating or semi-rotating, and pulverised fuel fired.

The Brackelsberg patent rotary melting furnace is claimed to be the latest developments of pulverised fuel firing for the purpose of melting iron and other alloys. It is stated the advantage of using pulverised fuel is, that it is the most efficient and easily controlled method of firing, which forms an essential part of the Brackelsberg process, that it is possible to maintain an absolute control of the physical and chemical properties of the product. These furnaces are constructed in various sizes and capacities from 1 ton upwards.

The complete installation consists of a pulverising mill, a bunker to hold the pulverised coal, and the furnace proper. The furnace consists of a cylindrical body with cone-shaped ends. It can be rotated for melting and tipped for tapping, charging and re-lining. It is lined with a high-grade refractory plastic. The procedure of charging, melting and tipping is as follows:—The balanced furnace is tipped by a small motor into an oblique position, and the charge is poured through a shute from an overhead charging platform. The furnace is then lowered into the horizontal position. The burner is inserted and the supply of pulverised fuel with air is turned on and ignited. The fuel flame passes above the charge and does not impinge on it. After the charge has been melted and brought to the correct pouring temperature the rotary movement is stopped. The furnace is then tapped by tipping and by pouring the molten metal from under the slag, after which the furnace is tipped in the reverse direction. The slag is thrown out and the furnace is ready for re-charging.

(*To be continued.*)

Sterling

MOULDING BOXES

Stand up to the exacting Requirements of the Modern Foundry

because

They are made from Rolled Steel

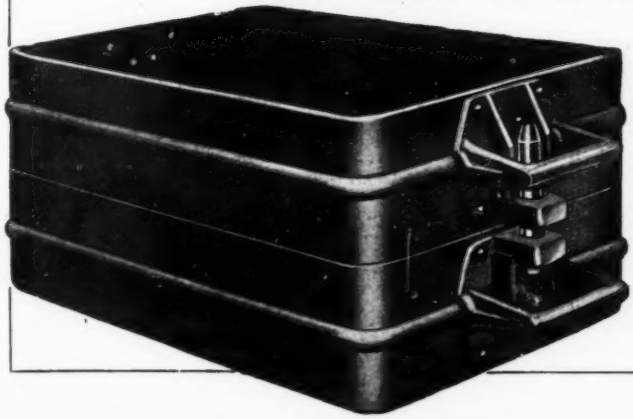
Over 2,500 pairs of STERLING BOXES are in daily use in the Foundry of Messrs. THOS. L. HALE (Tipton) LTD., DUDLEY PORT, Malleable Ironfounders.

Photo by courtesy of Messrs. THOS. L. HALE (Tipton) Ltd.

STERLING

FOUNDRY SPECIALTIES LTD.,

BEDFORD.



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13, VICTORIA STREET, S.W.1.

YOU CAN RELY ON THE NAME

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	27 11 3
Three months	27 6 3
Electrolytic	31 10 0
Tough	30 0 0
Best selected	30 10 0
Sheets	59 0 0
India	41 0 0
Wire bars	34 3 9
Do., July	33 12 6
Do., Aug.	33 0 0
Ingot bars	34 3 9
H.C. wire rods	36 0 0
Off. av. cash, May	28 11 11½
Do., 3 mths., May	28 12 7½
Do., Sttlmnt., May	28 11 9½
Do., Electro, May	33 6 8
Do., B.S., May	31 16 4½
Do., wire bars, May	33 16 8
Solid drawn tubes	9½d.
Brazed tubes	9¾d.
Wire	6½d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	7¾d.
Rods, extd. or rlld.	4¾d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	6½d.
Yellow metal rods	4¾d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN.

	£ s. d.
Standard cash	116 5 0
Three months	118 10 0
English	118 0 0
Bars	117 5 0
Straits	118 5 0
Australian	115 15 0
Eastern	120 10 0
Banca (nom.)	123 15 0
Off. av. cash, May	122 7 6
Do., 3 mths., May	124 10 1½
Do., Sttlmt., May	122 8 1½

SPELTER.

	£ s. d.
Ordinary	11 10 0
Remelted	10 10 0
Hard	9 5 0
Electro 99.9	14 0 0
English	12 10 0
India	11 5 0
Zinc dust	20 0 0
Zinc ashes	1 15 0
Off. aver., May	12 11 1½
Aver. spot, May	12 8 7½

LEAD.

	£ s. d.
Soft foreign ppt.	9 13 9
Empire	10 2 6
English	11 10 0
Off. average, May	10 17 1
Average spot, May	10 13 5½

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	23 0 0
Do., V.M. ex-whf.	20 10 0
Rods	27 0 0
Boiler plates	—
Battery plates	—

ANTIMONY.

	£ s. d.
English	35 0 0 to 42 10 0
Chinese	22 0 0
Crude	16 0 0

QUICKSILVER.

	£ s. d.
Quicksilver	11 15 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£8 5 0
45/50%	£13 0 0
75%	£19 0 0
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% c. free, of Mo.	6/3 per lb.
Ferro-titanium—	
23/25% carbon-free	11d. lb.
Ferro-phosphorus, 20/25%	£21 0 0
Ferro-tungsten—	
80/85%	2/- lb.
Tungsten metal powder—	
98/99%	2/3½ lb.
Ferro-chrome—	
2/4% car.	£27 15 0
4/6% car.	£25 0 0
6/8% car.	£24 10 0
8/10% car.	£23 15 0
Ferro-chrome—	
Max. 2% car.	£37 10 0
Max. 1% car.	£47 2 6
Max. 0.70% car.	£49 10 0
70%, carbon-free	1/1 lb.
Nickel—80/99.5%	£225 to £230
"F" nickel shot	£207 0 0
Ferro-cobalt	8/9 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	2/9 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 0 0
Metallic manganese—	
94/96% carbon-free	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	1 18 0	to 2 0 0
Bundled steel and shrngs.	1 15 0	to 1 18 0
Mixed iron and steel	1 15 0	to 1 16 0
Heavy cast iron	1 18 0	to 2 0 0
Good machinery for foundries	2 2 6	
Cleveland—		
Heavy steel	1 15 0	
Steel turnings	1 10 0	
Cast-iron borings	1 2 6	
Heavy forge	2 10 0	
W.I. piling scrap	2 2 6	
Cast-iron scrap	1 16 0	to 1 17 0
Midlands—		
Light cast-iron scrap	1 15 0	
Heavy wrought iron	2 7 6	
Steel turnings, f.o.r.	0 19 0	
Scotland—		
Heavy steel	1 15 0	
Ordinary cast iron	2 1 6	
Engineers' turnings	1 9 0	
Cast-iron borings	1 10 0	
Wrought-iron piling	2 2 6	
Heavy machinery	2 5 0	

London—Merchants' buying prices delivered yard.

	£ s. d.
Copper (clean)	23 0 0
Brass	15 0 0
Lead (less usual draft)	7 0 0
Tea lead	5 0 0
Zinc	6 0 0
New aluminium cuttings	72 0 0
Brassiery copper	19 0 0
Gunmetal	19 0 0
Hollow pewter	70 0 0
Shaped black pewter	50 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	61/-
Foundry No. 3	58/6
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	63/-
Hematite M/Nos.	62/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/-
,, d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands—	
Staffs common*	—
,, No. 4 forge*	61/-
,, No. 3 fdry.*	66/-
Shrops basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	57/6
,, fdry. No. 3*	62/6
,, fdry. No. 1*	65/6
Derbyshire forge*	61/-
,, fdry. No. 3*	66/-
,, fdry. No. 1*	69/-
,, basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	72/-
,, No. 3	69/6
Hem. M/Nos. d/d	68/6
Sheffield (d/d district)—	
Derby forge	58/6
,, fdry. No. 3	63/6
Lincs forge	—
,, fdry. No. 3	63/6
E.C. hematite	75/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby forge	62/-
,, fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	86/6
Clyde, No. 3	86/6
Monkland, No. 3	86/6
Summerlee, No. 3	86/6
Eglinton, No. 3	86/6
Gartsherrie, No. 3	86/6
Shotts, No. 3	86/6

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 7 6	to 9 15 0
Nut and bolt iron	7 15 0	to 8 10 0
Hoops	10 10 0	to 12 0 0
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	10 10 0	to 12 0 0
Bolts and nuts, ¾ in. × 4 in.	12 0 0	
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	8 7 6	to 9 5 0
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ¾ in. (Untested)	8 12 6	& up.
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 0 0	
Hoops (Staffs)	9 10 0	
Black sheets, 24g.	8 0 0	to 8 10 0
Galv. cor. shts.	9 5 0	to 10 0 0
Galv. flat shts.	9 15 0	to 11 0 0
Galv. fencing wire, 8g. plain	12 7 6	
Billets, soft	4 17 6	to 5 7 6
Billets, hard	6 12 6	
Sheet bars	4 15 0	to 5 5 0
Tin bars	4 15 0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	11½d.
Rods	10½d.
Tubes	16d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	14.84
No. 2 foundry, Valley	14.50
No. 2 foundry, Birm.	11.00
Basic	15.89
Bessemer	16.89
Malleable	16.89
Grey forge	16.39
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	43.00
Billets	27.00
Sheet bars	26.00
Wire rods	37.00
	Cents.
Iron bars, Phila.	2.11
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Skelp, sheared steel	1.60
Steel hoops	1.65
Sheets, black, No. 24	2.20
Sheets, galv., No. 24	2.85
Wire nails	1.95
Plain wire	2.20
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	22/6 to 25/-
,, furnace	16/- to 17/-
Durham and Northumberland—	
,, foundry	21/- to 25/-
,, furnace	13/- to 13/6
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	14/9 to 15/3
,, 28×20 ,,	29/6 to 30/6
,, 20×10 ,,	—
,, 18¾×14 ,,	—
C.W. 20×14 ,,	—
,, 28×20 ,,	—
,, 20×10 ,,	—
,, 18¾×14 ,,	—

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 0 0
Bars, hammered, basis	£16 10 0 to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6 to £16 5 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

XUM

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
June	16 ..	27	6	3	inc. 2/6
,,	17 ..	27	16	3	,, 10/–
,,	20 ..	28	2	6	,, 6/3
,,	21 ..	27	11	3	dec. 11/3
,,	22 ..	27	11	3	No change

Electrolytic Copper.

		£	s.	d.	
June	16 ..	31	0	0	No change
,,	17 ..	31	10	0	inc. 10/–
,,	20 ..	31	10	0	No change
,,	21 ..	31	10	0	,, ,,
,,	22 ..	31	10	0	,, ,,

Standard Tin (cash).

		£	s.	d.	
June	16 ..	112	0	0	inc. 15/–
,,	17 ..	114	0	0	,, 40/–
,,	20 ..	114	10	0	,, 10/–
,,	21 ..	113	15	0	dec. 15/–
,,	22 ..	116	5	0	inc. 50/–

Tin (English ingots).

		£	s.	d.	
June	16 ..	113	15	0	inc. 15/–
,,	17 ..	115	10	0	,, 35/–
,,	20 ..	116	0	0	,, 10/–
,,	21 ..	115	5	0	dec. 15/–
,,	22 ..	118	0	0	inc. 55/–

Spelter (ordinary).

		£	s.	d.	
June	16 ..	11	11	3	inc. 3/9
,,	17 ..	11	16	3	,, 5/–
,,	20 ..	11	12	6	dec. 3/9
,,	21 ..	11	11	3	,, 1/3
,,	22 ..	11	10	0	,, 1/3

Spelter (Electro, 99.9 per cent.).

		£	s.	d.	
June	16 ..	14	2	6	inc. 2/6
,,	17 ..	14	10	0	,, 7/6
,,	20 ..	14	5	0	dec. 5/–
,,	21 ..	14	0	0	,, 5/–
,,	22 ..	14	0	0	No change

Zinc Sheets (English).

		£	s.	d.	
June	16 ..	23	0	0	No change
,,	17 ..	23	0	0	,, ,,
,,	20 ..	23	0	0	,, ,,
,,	21 ..	23	0	0	,, ,,
,,	22 ..	23	0	0	,, ,,

Lead (English).

		£	s.	d.	
June	16 ..	11	5	0	No change
,,	17 ..	11	10	0	inc. 5/–
,,	20 ..	11	10	0	No change
,,	21 ..	11	10	0	,, ,,
,,	22 ..	11	10	0	,, ,,

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1894	0 12 6	0 12 6	0 12 7½	0 12 1½	0 12 4	0 12 1	0 12 0	0 12 0½	0 11 10½	0 12 2	0 12 0	0 12 0	0 12 1½
1895	0 12 0	0 12 0	0 11 10	0 12 0	0 12 0	0 12 3	0 12 3	0 12 4	0 12 4	0 12 6	0 12 7	0 12 6	0 12 2½
1896	0 12 6	0 12 6	0 12 9	0 12 9	0 12 9	0 12 7	0 12 9	0 12 9	0 12 9	0 13 6	0 15 0	0 14 9	0 13 1
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8½
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 8
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 0	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 1 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 2 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 2½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 5½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 5	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 0½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 2½
1913	1 2 9	1 2 2	1 1 7½	1 1 1	1 1 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 5½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 5½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	Price Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9½	1 4 2½	1 3 3½	1 2 6	1 2 3	1 5 2½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6*	1 1 0*	1 1 6*	1 1 6*	*	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	1 1 11	1 2 4½	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 2½
1929	1 2 6	1 2 6½	1 2 11½	1 3 0	1 3 0	1 3 2½	1 4 0	1 4 8½	1 4 7½	1 4 6	1 4 6	1 4 3	1 3 7½
1930	1 3 3½	1 2 6	1 1 9	1 1 6	1 0 10½	1 0 0	1 0 0	0 19 6	0 19 0	0 17 4½	0 16 4½	0 16 4½	0 19 10½
1931	0 16 1½	0 16 0	0 16 0	0 15 11½	0 15 4½	0 15 0½	0 14 10½	0 14 3½	0 14 6	0 16 8½	0 17 0½	0 16 6	0 15 9
1932	0 16 6	0 16 6	0 16 3	0 15 6	0 15 4½	—	—	—	—	—	—	—	—

* Prices nominal.

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